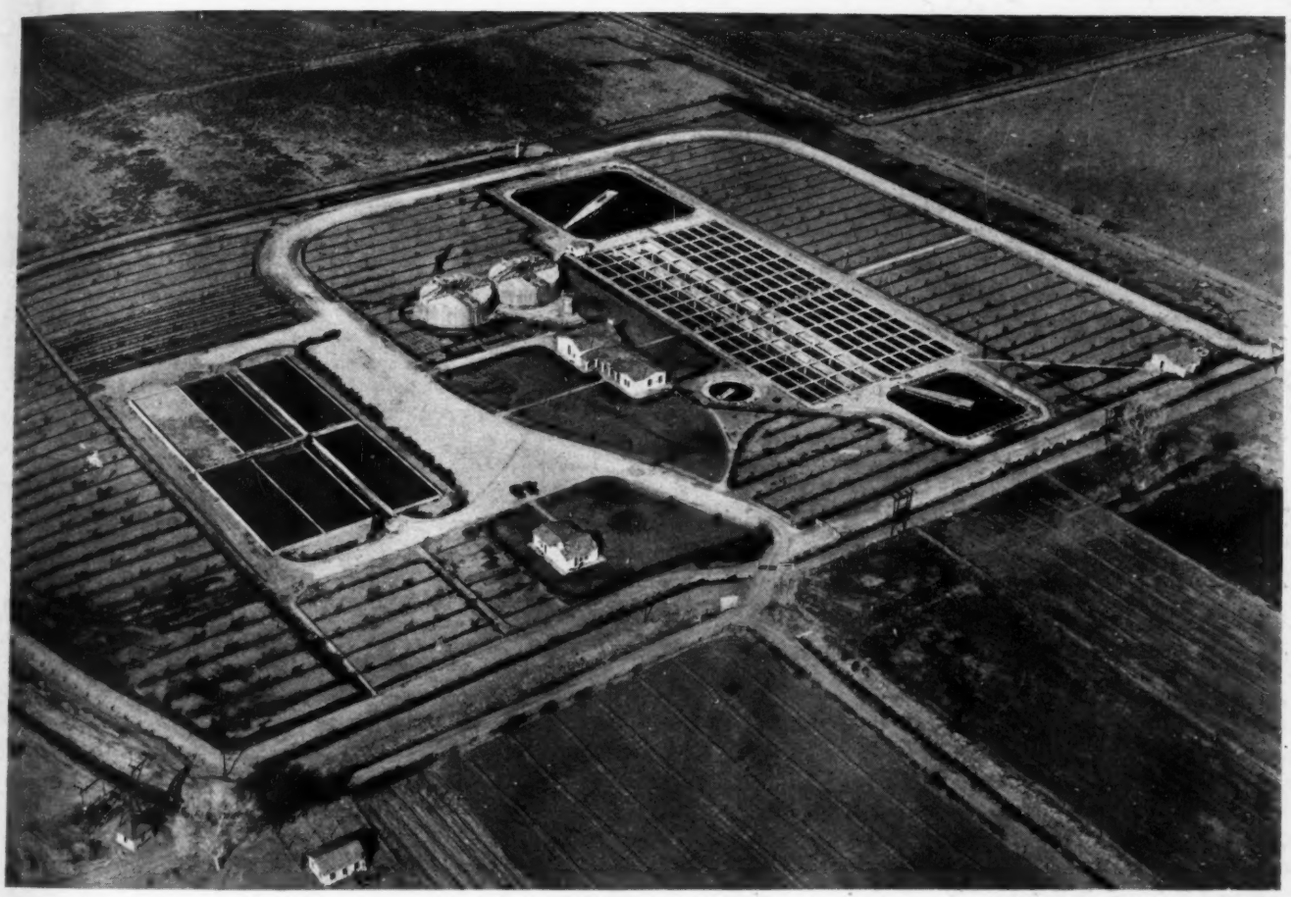
WATER WORKS AND SEWERAGE

April, 1934 — Editor — Vol. LXXXI. No. 4



Sewage Treatment Works of Phoenix, Ariz. (Clyde C. Kenedy, Engineer)

PHOTO BY FAIRCHILD AERIAL SURVEYS

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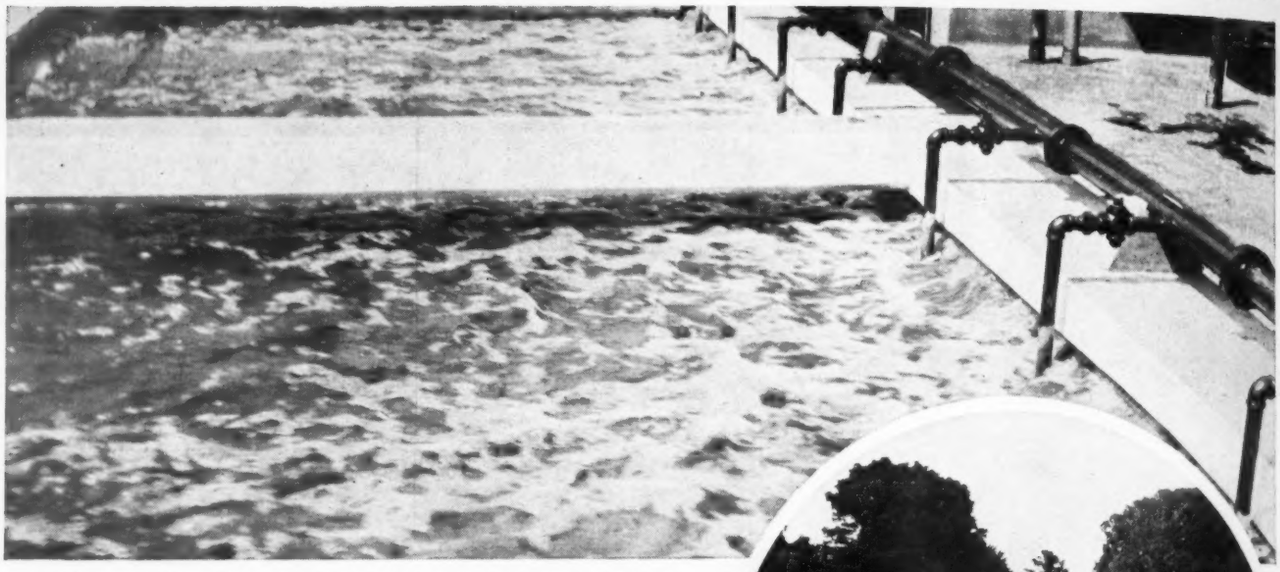
Practical Hydraulic Problems
Sludge Thickening at Phoenix, Ariz.
Corrosion of Well Casings by Electrolysis
A Study of Filtering Material for Rapid Sand Filters
The Installation and Servicing of Porous Air Diffuser Mediums
Report of 26th Annual Meeting of the New Jersey Sewage Works Association

NRA MEMBER U.S. WE DO OUR PART

FORCEFUL FACTS ON SEWAGE AERATION BY AIR DIFFUSION - No. 3



Close-up of one Aeration Tank, Golden Gate Park Plant, San Francisco, California. Equipped with Aloxite Brand Diffusers. Henry E. Elrod, Consulting Engineer, Houston, Texas. Frank McQueen, Resident Engineer.

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WATER WORKS & SEWERAGE

L. H. ENSLOW, Editor

LEADING ARTICLES To Appear in the Next and Subsequent Issues:

E. E. Jacobson, Chief Engineer and Clark Cramer, Station Engineer, Lexington (Ky.) Water Company, in an article of unusual interest — "Water Works Kinks"—give numerous practical operating "kinks" in purification, pumping and distribution practices which every water works man will be interested in and find useful. Martin E. Flentje, Chief Chemist of Community Water Service Company contributed several of the "kinks" included in the article.

N. T. Veatch, Jr., Consulting Engineer, Kansas City, Mo., will discuss values to be recovered from "The Utilization of Sewage" and the byproducts of sewage treatment. The most recent development is the plant designed in Mr. Veatch's office for Herington, Kansas, the financing being based on income from the sale of effluent for industrial usage by a railroad.

Alexander Potter, Consulting Engineer, New York City, reports the result of a study of the "Coefficient of Friction of a Cast Iron Sewer After 30 Years Service" which gives a picture of the condition of the structure and its carrying capacity after that length of service.

Richard H. Ellis, Water Commissioner and Superintendent of Water Works, Newton, Mass., will describe what is believed to be the most modernized and efficient meter shop arrangement and meter repair and maintenance practice in the East. His article will be of particular interest to Superintendents.

P. J. Holton, Jr., Superintendent and E. L. Bean, Chief Chemist, Division of Collection and Purification, Providence, R. I., Water Department, tell of the successful adaptation, advantage and economy of ferric iron compounds as coagulants at the Providence Filtration Plant.

C. P. Hoover, Superintendent Water Purification, Columbus, O., and a nationally known expert on water treatment problems, will discuss the economic aspects of water softening, the mechanics of softening and the comparison of the processes now employed.

Henry W. Taylor, Consulting Engineer, New York City, describes design of a separate sludge digestion sewage treatment plant which embodies unique and special features.

W. L. Eisert, Manager, Riverton Consolidated Water Company, in an article on "Advertising" recounts successful methods of building consumer and community good-will toward the local water utility.

John R. Downes, Superintendent, Sewage Treatment Works, Plainfield, N. J., will describe the new spray drying sludge installation at his plant—and its operation.

Dr. H. Bach, Chief Chemist, Emscher River Board, Essen, Germany relates a novel method of treating water by passage through metallic magnesium turnings for the purpose of dechlorinating or deacidification of corrosive waters, by complete CO_2 removal and pH adjustment.

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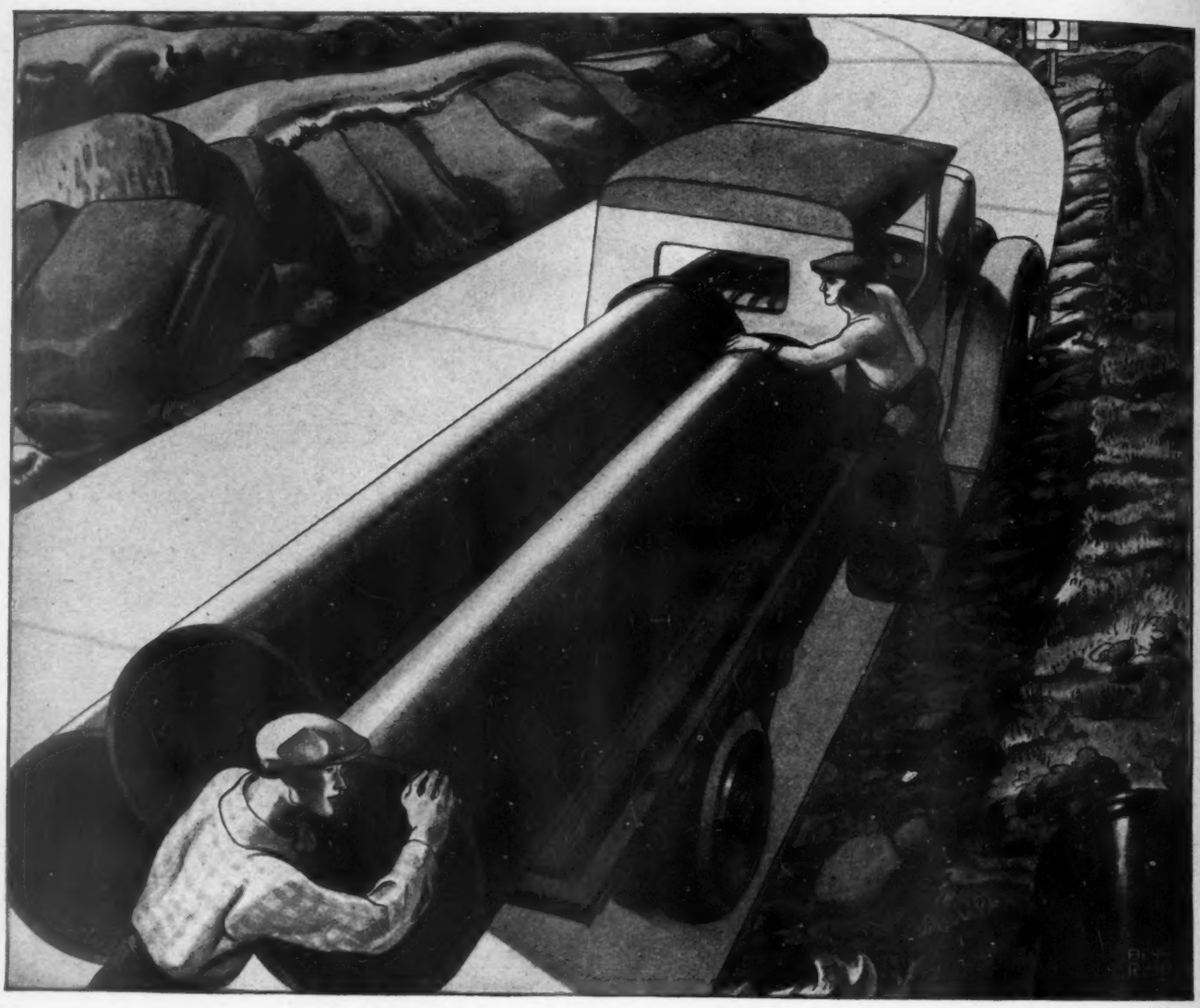

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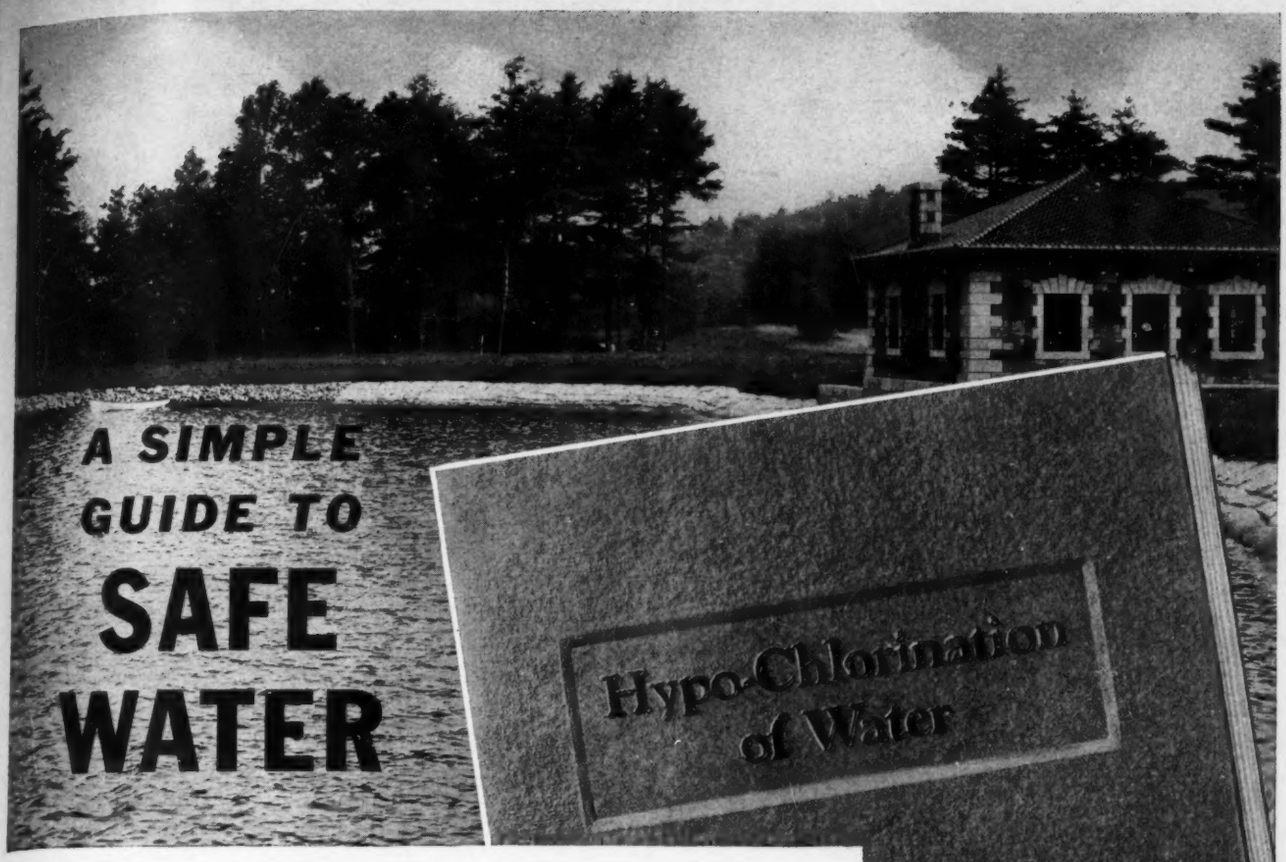

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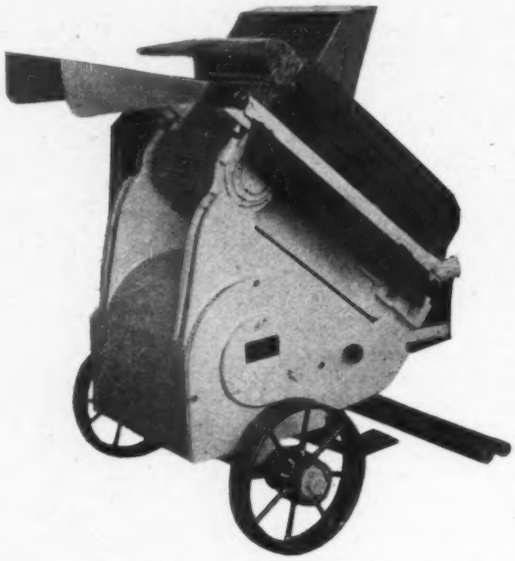

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*See July 1933 Issue WATER WORKS & SEWERAGE, for complete story.

Chlorination in Sewage Disposal

Report of the Committee on Sewage Disposal of the Engineering Section

American Public Health Association

presented at the Sixty-second Annual Meeting at Indianapolis, October 10, 1933

THE Report on Sewage Disposal is a detailed review of the use of chlorination in sewage treatment, in its various phases. It contains a brief resume of the history of chlorination, the methods of application, the theories of chlorination, the effect of chlorination upon raw sewage and various treated sewages. Particular stress is given to a study of the removal of B. O. D. and the effect of chlorinated effluents upon the streams. The use of chlorination in the control of sewage treatment operations and its effect in reduction of odors is covered, as well as its effect upon sludge digestion. Its use in connection with large scale projects to protect bathing beaches and water supplies is also noted. Numerous, up-to-date references are given, with sufficient excerpts to indicate the results obtained by various authorities, and their conclusions. It should prove of interest to everyone who is interested in handling sewage and will be of value to those more particularly concerned with water supply as well.

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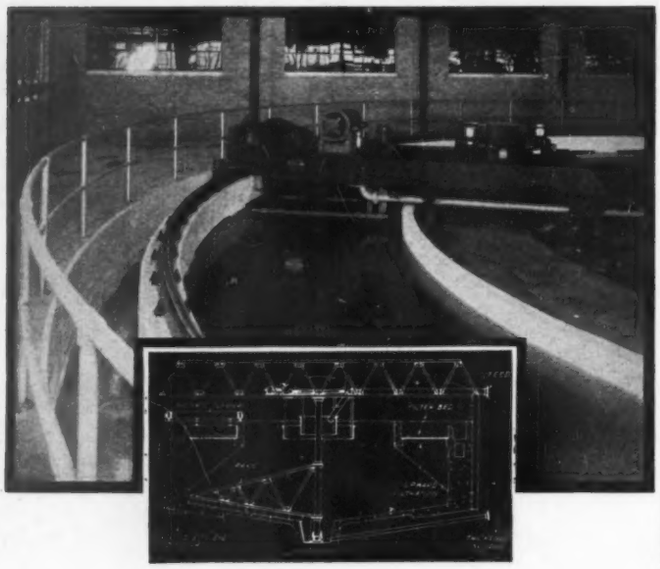

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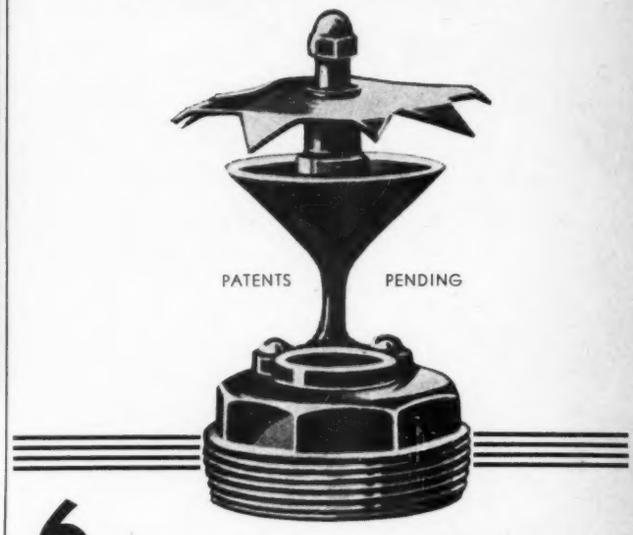

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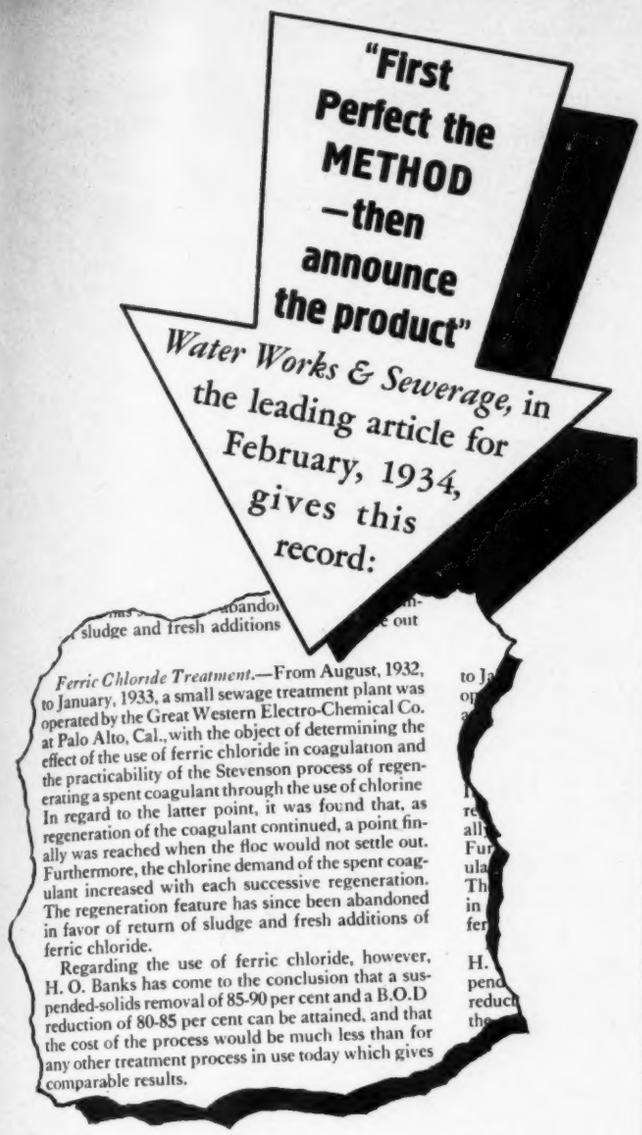
"First Perfect the METHOD —then announce the product"
Water Works & Sewerage, in the leading article for February, 1934, gives this record:
sludge and fresh additions
Ferric Chloride Treatment.—From August, 1932, to January, 1933, a small sewage treatment plant was operated by the Great Western Electro-Chemical Co. at Palo Alto, Cal., with the object of determining the effect of the use of ferric chloride in coagulation and the practicability of the Stevenson process of regenerating a spent coagulant through the use of chlorine In regard to the latter point, it was found that, as regeneration of the coagulant continued, a point finally was reached when the floc would not settle out. Furthermore, the chlorine demand of the spent coagulant increased with each successive regeneration. The regeneration feature has since been abandoned in favor of return of sludge and fresh additions of ferric chloride.
Regarding the use of ferric chloride, however, H. O. Banks has come to the conclusion that a suspended-solids removal of 85-90 per cent and a B.O.D reduction of 80-85 per cent can be attained, and that the cost of the process would be much less than for any other treatment process in use today which gives comparable results.

Great Western engineers have always adhered rigidly to the rule that the method of using a Bear Brand product should go hand in hand with the sale of the product itself. In the sanitation field, Great Western engineers produced the first electrolytic chlorine on the Pacific Coast; they introduced chloramine treatment of water supplies and sewage wastes on the Coast, using Bear Brand Chlorine and Ammonia; and they developed the ferric chloride treatment of water supplies and sewage wastes.

Their services for consultation on water purification and sewage disposal problems are available without charge.

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Plant: Pittsburg, Calif.

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1934 — still pioneering the advances in water works and sewerage metering and controlling

Builders Iron Foundry pioneering began with the Venturi Meter in 1891. Four quotations from a single issue (Feb., 1934) of "Water Works and Sewerage" give evidence that this technical leadership is still maintained.

Exhibit A Page 59 Feb., 1934 Water Works & Sewerage

Report of Committee on Water Supply Engineering, T. H. Wiggin, Chairman (Consltg. Engr. N. Y.) "As to flow measuring devices; a 10-ft. Parshall Flume utilizing the principles of a Venturi Meter had been installed at Providence, R. I., indicating that this structure was beginning to find application in the water works and sewerage field as an economical and accurate measuring device."

Builders Iron Foundry collaborated in the design of this flume and adapted a Type Y Register for use with it. Write for a description.

Exhibit B Page 64 Feb., 1934 Water Works & Sewerage

Recording Depth Gauge Warns of Intake Troubles, by Carl Leipold, Supt. Filtration, Winnetka, Ill. "The operator was aware from the chart record that anchor ice on intake strainers ..... the chart indicated anchor ice troubles were being relieved. This method of chart records . . . has proven to be of much value as a warning to prepare for intake troubles, and the taking of measures necessary to eliminate them."

Special applications for special needs have always featured Builders Iron Foundry work in this field. What are your problems?

Exhibit C Page 40 Feb., 1934 Water Works & Sewerage

Developments in Sewerage and Sewage Treatment During 1933, by Harrison P. Eddy, Pres. Amer. Soc. Civil Engrs. "An interesting application of the Venturi Meter has been made at the North Toronto sewage treatment plant. There Venturi rate-controllers are being installed, by means of which the flow of "return sludge" discharged into the settled sewage can be regulated in a positive manner. The rate-controllers are located on the sludge lines from the final sedimentation tanks and are set by hand to provide the desired rate of flow.

This application was suggested by Builders. Their engineers *know* water works and sewerage problems. They can help you, too.

Exhibit D Page 39 Feb., 1934 Water Works & Sewerage

Also from Pres. Eddy's paper. ". . . K. R. Kennison described the measurement of sewage flow by means of a new type of open nozzle. This nozzle was developed by the engineering staff of the Met. Dist. Water Supply Comm. of Mass. . . . It makes possible the accurate measurement of low flows. . . ."

A Type Y Register has been adapted for use with this interesting flow nozzle, too.

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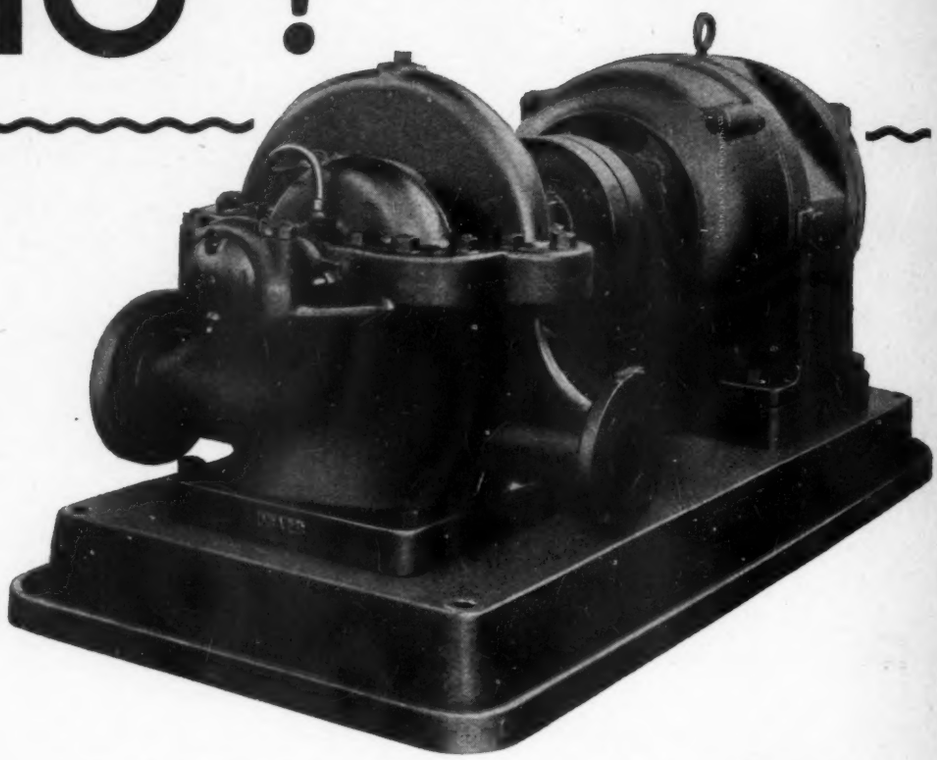

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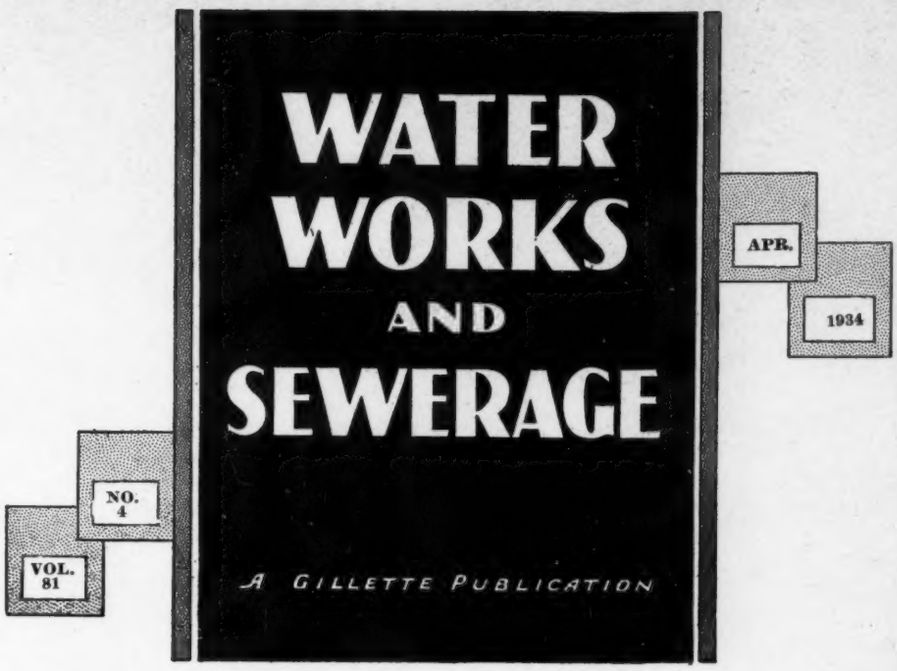


SLUDGE THICKENING AT PHOENIX, ARIZONA

By Reducing Supernatant Liquor Problem Improves Plant Operation

By D. TRAVAINI
Superintendent Sewage Treatment Works, Phoenix, Ariz.

FUNDS for the construction of the sewage treatment plant at Phoenix, Arizona, were limited, as is so often the case. The plans called for an activated sludge plant with Dorrco aerators, and separate digestion of mixed crude sludge solids and the wasted activated sludge. In order to effect economies it was decided to postpone construction of one of the three 60-ft. digesters provided the waste activated sludge could be thickened to reduce the volume of sludge pumped to the digesters and thereby the required digester capacity. Mr. C. C. Kennedy, Consulting Engineer, who designed the plant, provided a sludge thickener for this purpose.

The Sludge Thickener

The sludge thickener, as constructed, is a circular tank 35 ft. in diameter with an effective depth of 9 ft. at the periphery of the tank with 1 ft. of free board above the water level. The thickening mechanism was supplied by the Dorr Company and consists of a picket fence made of 2-in. pipe on 6-in. centers extending 5 ft. above the bottom of the tank floor. This is attached to the bracing supporting the bottom scrapers. A skimming arm is also provided. See Fig. 1.

The tank is centrally located* and arranged so that waste activated sludge, mixed liquor, plant effluent, primary sludge, or digester overflow liquor can be admitted through pipe inlets at one side of the tank, approximately 18 ins. below the water level. A 24-in. redwood baffle 13 ft. long was provided in front of the pipe inlets.

The two rectangular ports, located 180 degrees from the inlet are 10 by 72 ins., the top being 10 ins. below the water level. The effluent passing through these ports overflows a notched weir, giving the effect of a baffled weir, thence through a 12-in. cast iron pipe to the inlet of the primary clarifier.

The original baffle at the inlet was not satisfactory. Short circuiting was so pronounced that it prevented effective utilization of the tank capacity. After considerable investigation, a Sacramento baffle was installed in May, 1933, and ended the short circuiting troubles. We attribute the successful use of the thickener to this baffle and the installation of a Wallace and Tiernan chlorinator made at the same time, the value of which will be discussed later. Before these improvements were made we were prone to look upon the thickener as a liability rather than an asset.

The Sacramento type baffle was developed under the direction of Professor Charles Gilman Hyde over ten

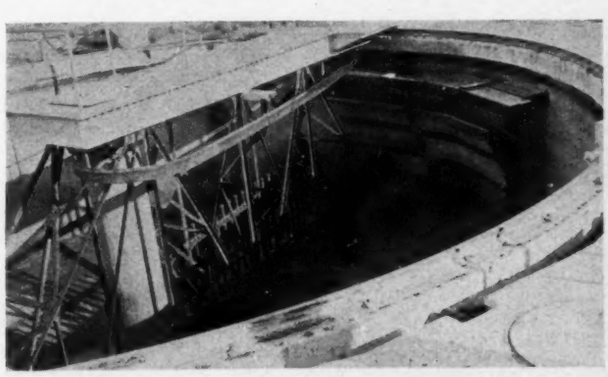


Fig. 1—Thickener Mechanism Showing Picket Fence Bottom Scrapers and the Sacramento Type Inlet Baffle.

*See aerial view of plant on front cover.

Fig. 2—Sacramento Baffle and One of the Three Chlorine Hose Inlets.

years ago. The structure built at Phoenix consists of a redwood baffle 24 ins. from the wall at the water surface, tapering to 9 ins. at the wall 36 ins. above the intersection of the vertical wall and sloping bottom. This baffle is perforated with 4-in. square openings on 18-in. centers, both ways. Nine inches in front of these openings are suspended wooden baffle boards 10 ins. wide. See Figs. 2 and 3.

Operation of Thickener

Since the plant was first placed in service on March 15, 1932, the thickener operation has been diversified. We have used this structure to concentrate the following influents: 1. Primary sludge. 2. Wasted activated sludge. 3. Combined primary sludge and wasted activated sludge. 4. Waste mixed liquor. 5. Combined primary sludge and waste mixed liquor. 6. Digester overflow. The results obtained varied considerably and with some of the operations odor nuisance became a serious problem.

Before August, 1932, no laboratory data was available on the thickener. Our laboratory was installed in June, 1932, but with an inexperienced crew and no chemist, a great deal of data was sacrificed. The routine analyses, made in connection with the thickener operation, are the per cent solids of the influent sludge and the per cent solids of the thickened sludge. In performing these analyses we also determine the pH and per cent of volatiles. We have trained our operators to maintain a thickener of effluent reasonably free from solids, and their judgment is checked intermittently with laboratory tests.

Our first attempt with the thickener was to concentrate primary sludge, with digester overflow liquor, also being passed through the thickener during the latter part of March and early April, 1932. Fair results were obtained in thickening the sludge, but with high atmospheric temperatures and a septic digester overflow, a heavy scum would form on the tank in spite of the action of the scum skimmer, and an odor nuisance was created. Odor nuisance could not be tolerated, so the thickener was removed from service until activated sludge could be wasted.

On June 2, 1932, activated sludge had built to a point where wasting could proceed, and the thickener was again placed in service. Waste activated sludge, primary sludge, and digester overflow were concentrated. Scum on the tank, and odors prevailed due to the conditions already mentioned, and short circuiting was apparent, consequently wasting of activated sludge had to be reduced to prevent excessive quantities of septic floc from flowing from the thickener to the primary clarifier. In order to avoid the bad condition caused by the digester overflow, this was diverted from the thickener to the sludge drying beds. With this change we were able to increase the amount of sludge wasted, odors and scum were also materially reduced. We were still unable, however, to hold the sludge in the thickener sufficiently long to obtain the degree of concentration anticipated when the tank was designed. When we attempted to hold it to increase the solid content to the point anticipated, the sludge would rise and odors became pronounced. During this period our atmospheric temperatures were well over 100 F. in the shade, and the tank temperature varied from 80 F. to 87 F. Under these conditions bacterial action is so rapid that we could not

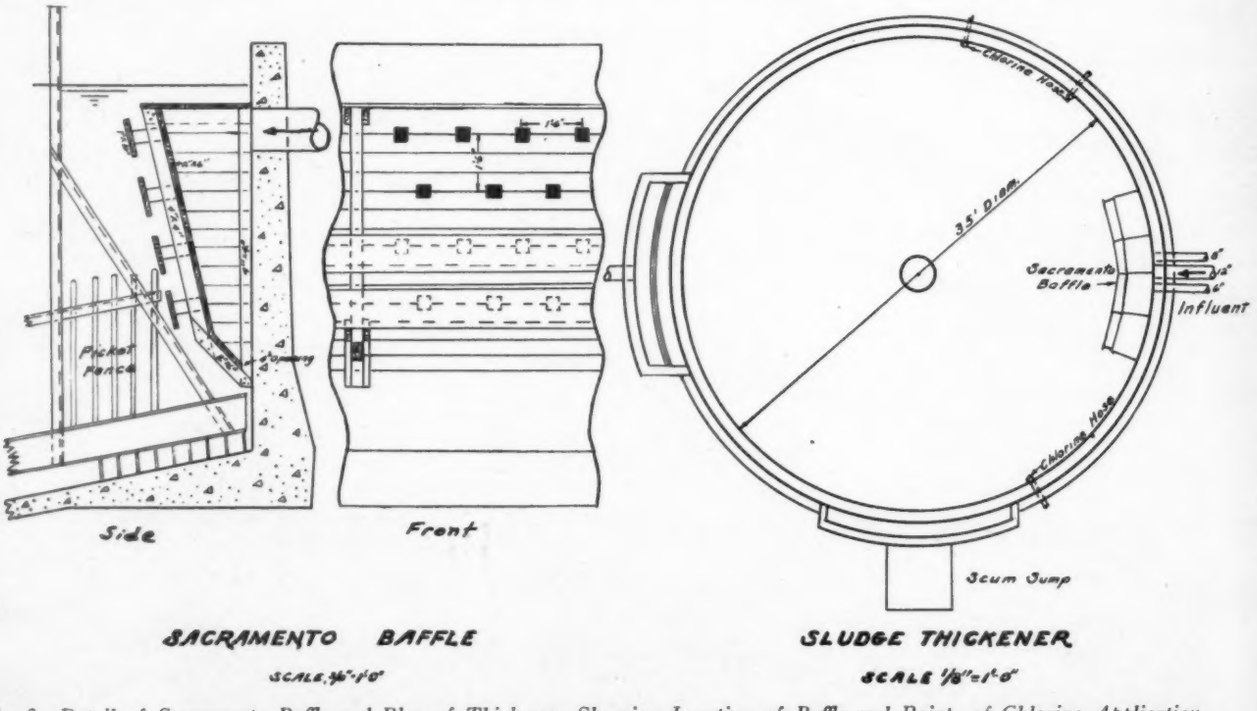


Fig. 3—Detail of Sacramento Baffle and Plan of Thickener, Showing Location of Baffle and Points of Chlorine Application.

Fig. 4—Primary Clarifier, Aerators, Digesters and Gas Holder, Blower House, Phoenix, Ariz., Sewage Treatment Plant. (Thickener Is Between Primary Clarifier and Blower House.)

obtain the concentration desired without some provision to retard septic action.

Attempts to Control Septicity

In the early part of October, 1932, we arranged to return plant effluent to the thickener, hoping that the dissolved oxygen in the effluent would retard septic action and thus eliminate odors and allow a longer sludge holding period. This procedure aggravated the short circuiting in the tank and caused the solids in the effluent to increase materially. Since short circuiting made it impossible to waste the desired quantity of activated sludge when sufficient plant effluent was being passed through the thickener to retard bacterial action, we reduced the quantity of plant effluent and tried the intermittent use of lime and chlorinated lime to effect the desired results. The lime served a dual purpose: first, it caused the sludge to settle rapidly; second, by adding a sufficient quantity to keep the pH of the supernatant above 8.5, it inhibited bacterial action allowing us to increase the holding period of the solids. The lime was applied by pumping milk of lime to the thickener intermittently. A solution of chlorinated lime was added continuously. This operation was continued as shown in table No. 1 from October, 1932, to May, 1933. First we thickened combinations of primary sludge with waste activated sludge; then we concentrated the activated sludge alone; later we concentrated primary sludge alone. Odors and scum were eliminated, and good thickening was procured as indicated in table No. 1. The

Table No. 1

THICKENER DATA

Date	Aver. gals./day of primary sludge to thickener	Aver. % solids in primary sludge	Aver. Gals./day of returned activated sludge wasted to thickener	Aver. % solids in waste ret. act. sludge	Aver. gals./day of mixed liquor wasted to thickener	Aver. % solids in mixed liquor	Aver. lbs. of hydrated lime per day to thickener	Aver. lbs. of chloride of lime per day to thickener	Aver. lbs. of chlorine per day to thickener	Aver. % solids in thickened sludge pumped to digesters
Aug. 1932	21460	2.75	67170	0.910	—	—	0	0	—	3.20
Sept. 1932	36100	2.84	50250	0.825	—	—	0	0	—	3.96
Oct. 1932	21309	5.28	47230	0.757	—	—	150	23	—	5.80
Nov.(1-14)1932	18845	4.99	32300	0.772	—	—	151	53	—	4.73
Nov.(15-30)1932	—	—	43200	0.940	—	—	104	21	—	3.85
Dec.(1-8)1932	—	—	47200	0.732	—	—	0	10	—	3.97
Dec.(22-31)1932	31600	7.63	—	—	—	—	82	30	—	9.78
Jan. 1933	27000	7.99	—	—	—	—	120	20	—	10.81
Feb. 1933	24130	7.81	—	—	—	—	0	12	—	11.13
Mar.(1-12)1933	21320	6.99	—	—	—	—	18	7	—	8.79
Mar.(20-31)1933	23450	6.85	42240	0.435	—	—	58	14	—	6.08
April 1933	23100	5.12	44700	0.582	—	—	61	10	—	4.97
May 1933	Installing Sacramento baffle — Chlorinator — Testing.									
June 1933	22805	4.73	—	—	81356	0.132	0	0	47	5.59
July(1-16)1933	19030	3.87	21400	0.643	—	—	0	0	45	4.21
July(17-26)1933	—	—	20520	0.610	—	—	0	0	38	4.66
Aug. 1933	—	—	—	—	79260	0.213	0	0	35	5.94
Sept. 1933	—	—	—	—	20880	0.197	0	0	30	4.22
Oct 1933	—	—	—	—	42030	0.247	0	0	35	4.98
Nov. 1933	—	—	—	—	89530	0.223	0	0	38	3.78
Dec. 1933	—	—	—	—	135300	0.153	0	0	35	3.83
Jan. 1934	—	—	—	—	53660	0.166	0	0	38	4.35
No laboratory results on Thickener prior to Aug. 1932										

ash content of the thickened sludge increased from 2 to 3 per cent.

During the early part of November the suction lines of the sludge pumps were changed so that primary sludge and thickener sludge could be pumped simultaneously to the digesters, mixing the two sludges in the pump discharge line. With this arrangement we tried thickening waste activated sludge alone. With cool weather and the absence of primary sludge we were able to concentrate the activated sludge to approximately 4 per cent solids content with a material decrease in the quantity of lime and chlorinated lime required.

In the early part of December, 1932, the building of activated sludge stopped. This condition prevailed until the middle of March, 1933. During this period a strong phenolic odor prevailed over the plant. The plant effluent became turbid, and we attribute the unbalanced condition of the plant to the intermittent discharge of gas plant waste. In the spring when the Park Department again began using the gas plant waste for irrigation the condition of the plant returned to normal.

During this interval, however, we had the opportunity of concentrating primary sludge under cool weather conditions. Table No. 1 shows that the sludge pumped from the thickener to the digesters averaged 9.78 per cent solids in the latter part of December, 10.81 per cent in January, 1933, and 11.13 per cent in February. The maximum concentration occurred on January 18, 1933, when the solids pumped from the thickener averaged 14.17 per cent. No odor or scum nuisance was created during this period and the amount of lime and chlorinated lime used was small due to the cool weather. This added concentration was beneficial because the digesters still had a tendency to foam, and the reduced quantity pumped to them decreased the volume of overflow (high in suspended solids) which was being applied to the drying beds.

Installation of Baffle and Chlorinator

The short circuiting in the thickener made it apparent that the original baffle was not efficient. Investigation revealed that operators using the Sacramento baffle praised its efficiency, so in May, 1933, we constructed one at the influent end of the thickener. We also installed a Wallace and Tiernan solution feed chlorinator in order to use liquid chlorine to retard septic action. With the chlorinator we anticipated accurate control of chlorine applied to the thickener, which was not possible under the crude conditions in which we were using lime and chloride of lime.

After completing the installations mentioned the thickener was not placed in service during the remainder of the month of May. We devoted our spare time to experiment, to determine the efficiency of the baffle and to find at which points to chlorinate the sludge input in order to obtain the best distribution of chlorine. The results obtained from the baffle were very gratifying. Using fluorescene dye and pumping plant effluent to the thickener we found very good distribution and practically no short circuiting, even when the flow was increased to the capacity of the 12-in. effluent line. By the trial and error method we adopted three points of

Table No. 2

THICKENER DATA

Date	Gals. of mixed liquor wasted	Chlorine #/24 hrs.	Influent (Mixed Liquor) pH	Influent (Mixed Liquor) % by volume 1 hr. settling	Influent (Mixed Liquor) Suspended Solids p.p.m.	Influent (Mixed Liquor) Suspended Solids % dry wt.	Effluent Total Solids p.p.m.	Effluent Suspended Solids-p.p.m.	Effluent B.O.D. p.p.m.	Effluent pH	Thickened Sludge % Solids dry weight	Thickened Sludge pH
1/18/34	144000	35	7.6	30	1620	0.162	1075	21	20	7.6	—	—
1/19/34	144000	35	7.6	42	1725	0.172	1007	31	24	7.6	4.021	7.6
1/20/34	132000	35	7.8	50	1823	0.182	1012	31	28	7.8	4.287	7.8
1/21/34	144000	35	7.8	55	1342	0.134	1000	16	38	7.8	3.937	7.8
1/22/34	132000	30	7.6	50	1865	0.186	938	42	36	7.6	3.571	7.8
1/23/34	234000	45	7.6	47	2339	0.234	1020	26	26	7.6	4.120	7.6
1/24/34	288000	53	7.6	42	1618	0.162	1074	37	46	7.6	4.090	7.6
1/25/34	207000	50	7.6	54	2232	0.223	1015	26	32	7.6	3.529	7.6
1/26/34	132000	50	7.6	40	1065	0.106	1045	13	16	7.6	3.996	7.6
1/27/34	172000	41	7.6	32	1255	0.125	909	38	30	7.6	3.827	7.6
1/28/34	158400	40	7.6	30	1863	0.186	1010	27	22	7.6	4.090	7.6
1/29/34	158400	36	7.8	28	1652	0.165	995	13	16	7.8	3.684	7.8

Date	Gals. of returned act. sludge wasted	Chlorine #/24 hrs.	Influent (Returned Activated Sldg.) pH	Influent (Returned Activated Sldg.) % by volume 1 hr. settling	Influent (Returned Activated Sldg.) Suspended Solids p.p.m.	Influent (Returned Activated Sldg.) Suspended Solids % dry wt.	Effluent Total Solids p.p.m.	Effluent Suspended Solids p.p.m.	Effluent B.O.D. p.p.m.	Effluent pH	Thickened Sludge % Solids dry weight	Thickened Sludge pH
2/9/34	70500	60	7.6	98	5243	0.524	1210	36	106	7.6	—	—
2/10/34	60300	65	7.8	88	5651	0.566	1163	43	126	7.8	3.618	7.8
2/11/34	45200	65	7.8	99	6920	0.692	1090	28	95	7.8	3.684	7.8
2/12/34	38500	55	7.8	99	7848	0.785	1215	45	152	7.8	3.262	7.8
2/13/34	54100	65	7.8	98	8132	0.813	1230	52	166	7.8	4.127	7.8
2/14/34	19200	50	8.0	98	7337	0.734	1140	38	120	8.0	4.006	8.0
2/15/34	30300	55	7.8	98	8243	0.824	1125	45	138	7.8	3.529	7.8
2/16/34	11040	40	7.8	98	9130	0.9130	1110	32	95	7.8	3.280	7.8

Note:- Results from 24 hr. composites.

TABLE III—CONCENTRATION OF SLUDGE IN THICKENER PER FOOT OF DEPTH

	Depth from liquid level in ft.	Nov. 3 1933	Dec. 11 1933	Jan. 20 1934	Feb 11 1934
% Solids in sludge at depth shown	3	—	0.25	0.27	0.810
	4	0.50	0.50	0.70	1.02
	5	1.20	1.05	1.15	1.35
	6	1.04	1.25	1.37	1.72
	7	1.20	1.40	1.55	2.38
	8	1.40	1.70	2.10	2.87
	9	3.50	3.25	3.75	3.05
	Cone.	4.08	4.21	4.28	3.68
% Solids in sludge—Influent		0.105	0.195	0.182	0.692
pH - Influent		7.8	7.8	7.8	7.8
pH—Thickened Sludge.		7.6	7.8	7.8	7.8
Suspended Solids p.p.m. - Effluent		20	25	31	28
B.O.D. - p.p.m. Effluent		—	30	28	95

Note:- Results from 24 hr. composites.

application of chlorine that gave the best distribution. The chlorine hoses are submerged 3 ft. below the liquid level in the tank. One point of application is 13 ft. along the periphery of the tank from the west end of the baffle. The other two points are 9 ft. and 18 ft., respectively, along the periphery of the tank from the east end of the baffle—see Figs. 2 and 3.

By varying the quantity of chlorine solution applied at the points mentioned even distribution of chlorine can be maintained.

With this preliminary work completed, during the early summer we tried concentrating primary sludge in combination with mixed liquor taken from the areation tanks; then primary sludge with returned activated sludge, and then returned activated sludge alone. Very good results were obtained as shown in Table No. 1.

The Scheme That Gave the Best Overall Results

In August, 1933, we decided to try concentrating mixed liquor only.[1] Our object was, that in summer the primary clarifier influent is stale and we felt that by adding to the crude sewage a sizeable flow of effluent from the thickener, containing dissolved oxygen and some residual chlorine, it would improve plant operating conditions. The amount of thickener effluent would naturally be much greater when concentrating sludge from mixed liquor than when concentrating returned activated sludge and therefore the greater benefit to the crude sewage.

The results obtained by thickening mixed liquor were so satisfactory, as shown in Table No. 1, that we adopted it as routine operation. The primary sludge is concentrated to approximately 5 per cent in the primary clarifier and mixed with the thickener sludge by pumping sludges from both tanks simultaneously.

In Table No. 2 analytical data of thickener operations are given for mixed liquor and when returned activated sludge is treated. Table No. 3 shows the solids content of the sludge at various depths. Since the installation of the Sacramento baffle and providing chlorination at a very nominal cost, we can maintain a clear overflow with the sludge blanket within 3 ft. of the liquid level, when wasting 200 gals. or less of mixed liquor or returned sludge to the thickener per minute.

Conclusions

Since we installed the Sacramento baffle and eliminated short circuiting, and since we started to chlorinate to retard bacterial action and thereby control septicity, the thickener has operated satisfactorily and accomplishes the purpose for which it was designed.

REFERENCE—

"'A New Method of Concentrating Activated Sludge," R. F. Goudey and S. M. Bennett. Water Works and Sewerage, May, 1933.

▼

To Make Coming A.W.W.A. Convention Biggest and Best Yet

William J. Orchard, President of the American Water Works Manufacturers Association and Chairman of the Committee on Convention Publicity, predicts that the coming 54th annual convention of the American Water Works Association (June 4-8) is to be one of the most instructive, interesting and entertaining conventions yet held.

"Because this year the meeting will be in New York City it will be possible," says Mr. Orchard, "to have present a number of very prominent men—consulting engineers, chemists, operators, management and finance authorities—whose work might otherwise prevent them from attending the convention were it held at some other point. The keenest cooperation of these men has been enlisted for this forthcoming convention. Their wealth of experience will be translated into terms of better water works practice that every operator can apply to his own particular job. Unofficial contact with them as they are present at the convention will give every operator an opportunity to question these authorities on problems that have been bothering them. In turn, the operators will have an opportunity to contribute their experience for the benefit of all.

Orchard promises further—

"Not only is the technical program of the convention to be one of the most instructive ever presented, but here in New York those attending the convention will have an opportunity to join in entertainment features not to be found anywhere else in the world.

"In addition, reports will be made of the activities of the National Recovery Committee for Water Works Construction and the part they have played to date in obtaining allocation of Federal funds in excess of $200,000,000 for the construction of water works and sewage projects and filing of applications for an additional $660,000,000 for further work.

Water works men cannot afford to stay away from New York City, June 4 to 8, 1934. Headquarters hotel is the Commodore, located at Grand Central Station, and if WATER WORKS AND SEWERAGE can assist in making reservations there or at other convenient hotels, we are at the service of our readers. Do not delay preparations to attend the 1934 convention.

CORROSION OF WELL CASINGS BY ELECTROLYSIS

By SHEPPARD T. POWELL
Consulting Chemical Engineer, Baltimore, Md.

Sheppard T. Powell

THE use of water from deep underground sources is highly desirable for many industrial processes especially where large quantities of water are necessary. Wells of this type are relatively costly to install but often produce large quantities of water and are fairly economical to operate provided there is no unusual corrosion of well casings on pumping and auxiliary equipment. The corrosive properties of such water at times, however, may be so excessive as to require abandonment of the supply.

The following discussion relates to corrosion difficulties experienced in a large manufacturing plant, where, during the past twenty years, many deep wells have been constructed. These wells have been established in three different strata and the underground supply has been drawn from water horizons between depths of 100 and 300 feet. Water from some of these strata has been fairly satisfactory and the corrosion experienced has not been particularly troublesome. On the other hand, the water from many of the wells has rapidly attacked ferrous and non-ferrous metals used in well construction. Much of the corrosion noted has been caused by acid salts in the water, particularly ferrous and aluminum sulphate. In one or two instances magnesium chloride, also, has contributed to the corrosion difficulties experienced.

The general construction of the type of wells under discussion (Fig. 1) consist of an outer casing and an inner casing, a deep pump and discharge pipe. Steel casing has been used generally, but in later years casings of Armco iron, with or without protective coatings, have been employed to cut down the corrosion losses. The corrosion noted in these wells has not been limited to any specific portion of the wells but has occurred on the outer and innerside of the casing, the pump runners and elsewhere. Although the corrosion difficulty with these underground water supplies has been a troublesome problem for a number of years, the type of corrosion noted has indicated the difficulty experienced to be largely that expected from waters of low pH value. In a recent failure of one of these wells, however, the condition of the casing indicated that electrolysis was playing an important part and had greatly accelerated the corrosion rate.

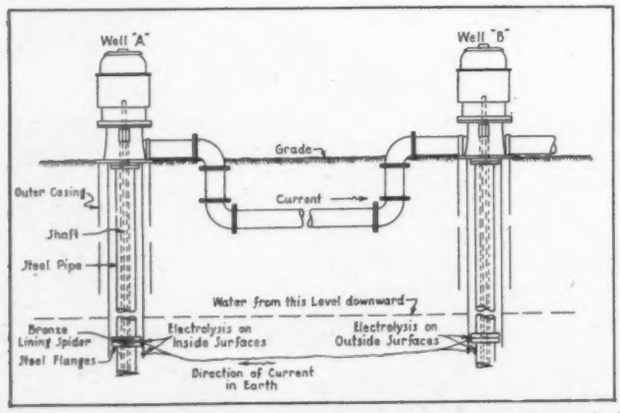


Fig. 1. Typical Diagram Showing Location of Electrolytic Corrosion on Inside and Outside Surfaces of Casings Depending on Direction of Current Flow.

The operation of the well in question having indicated a failure of the casing, it was decided to dismantle the well and examine the casing, pump and main discharge pipe. On examination it was noted that the corrosion had been excessive and the casing was perforated in several places, although the well had only been in operation for a relatively short period. Corroded areas were noted both on the outside and inside of the discharge line. The inspection further disclosed that the discharge pipe had been eaten through at one or two spots. Careful examination of these areas clearly pointed to electrolysis due either to external stray currents entering the wells through pipe lines or from galvanic action, which is set up when dissimilar metals make contact in the presence of an electrolyte. So many factors were involved in the problems that a rational explanation was not readily apparent. From a theoretical viewpoint it was assumed that each well casing would be comparable to a terminal immersed in a vast container, represented by the earth. The casing, in contact with a variety of electrolytes, would create a difference of potential and manifest itself in the form of a current. This condition is not improbable when it is realized that all wells are connected together by pipe-lines which serve to provide a large electric circuit. This theory was not fully substantiated by the data obtained but appeared to offer some explanation for the existing condition. It was decided, however that the difficulty experienced warranted an electrical survey to determine the existence of stray currents and to evaluate, if possible, the influence of these factors and the corrosion rate.

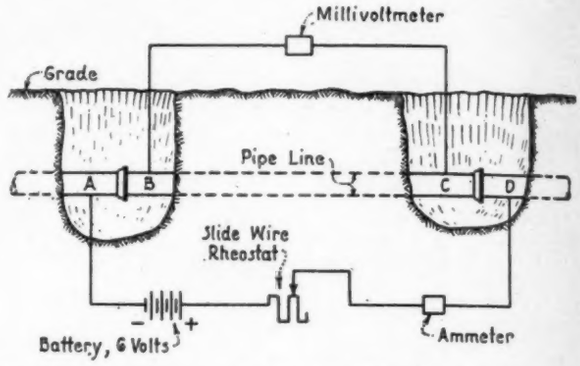


Fig. 2. Diagrammatic Arrangement Showing Location of Apparatus for Measuring Electric Current Along Pipe Lines.

Method Employed

The method employed in obtaining current measurement was first suggested by Dr. Carl Herring.[1] The procedure consists of uncovering a section of pipe-line approximately 35 ft. long and connecting the series of

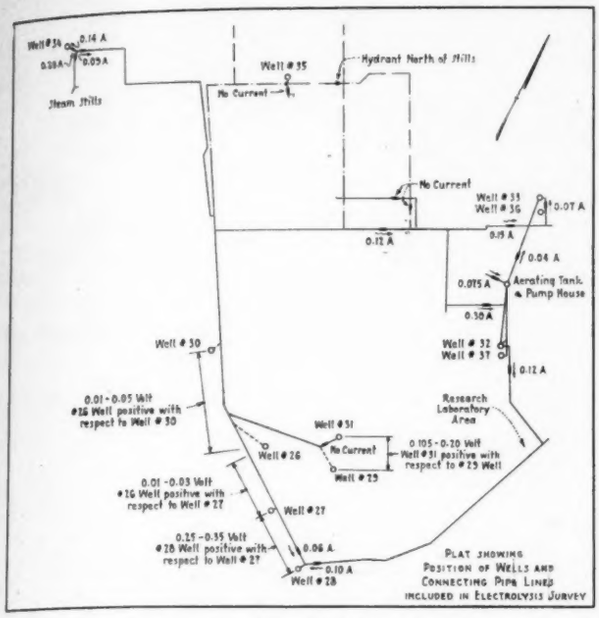


Fig. 3. Plat Showing Position of Wells and Connecting Pipe Lines Included in Electrolysis Survey.

instruments in a manner shown in Fig. 2. This procedure was followed with the exception that instead of uncovering the entire pipeline, two 6-ft. sections of the pipe were uncovered 35 ft. apart and then making the instrument connections in the same manner that would be followed if the entire pipeline had been uncovered. By this arrangement, any current flowing through the pipe will manifest itself by a potential drop along the pipe section connected to the millivolt meter, the direction of the meter indicating the direction of current flow. If, now, a current be impressed on the pipe section, which will accordingly oppose the current existing in the pipe, then there will be no current flow in the section of the pipe btween A and D which is common to the two circuits, and the millivolt meter reading will, therefore, be zero. The current which exists in the pipeline, however, cannot vanish on account of this external connection, and since the conditions are favorable, it will shunt its way through the battery, the rheostat, and the ammeter back to the line. When the millivolt meter, therefore, reads zero, the reading of the ammeter gives the current in the pipeline. A total of sixteen such readings were taken throughout the company's property and the direction and magnitude of the currents observed. These are reported in Fig. 3.

Observations

A number of interesting phenomena were observed in this study, but which cannot be reported here due to limited space. It is of interest to note, however, that there was a variation both in intensity and direction of flow of current in the same pipeline. This was indicated by readings taken between an elevated storage tank and the interconnecting pipe-lines between the wells and other parts of the water distribution system shown in Fig. 4. Current readings were obtained at the elevated tank, which is directly above one of the wells. The current in this line, supplying a water storage tank, averaged 0.075 amperes flowing towards the aeration tank. Other readings which were taken at the company's wharves on the pipeline between the wharves and the storage tank averaged 0.17 amperes and the current was flowing towards the drinking water storage tank. It will be noted from the sketch that the currents in the pipelines between the drinking water storage head tank and the two points noted were flowing in opposite directions. All of the above currents were very steady and, on the basis of the behavior of stray currents observed at other points in the yard, it was indicated that these currents were generated within the company's works. It was impossible to definitely trace the source of these currents, but it was suggested that they may have been caused by subsurface metallic structures such as pipelines, producing galvanic potentials of sufficient magnitude to force a current flow through certain sections. The difficulty of accurate differentiation and identification of the source of these currents was greatly involved, owing to the large number and the length of the various pipe lines on the company's property.

An interesting condition was noted in taking readings at active wells and at wells which had previously been abandoned. Data obtained from readings at the abandoned wells showed that the potential was fluctuating. Readings taken on the pipelines from all active wells were steady. The only explanation for this condition is that the abandoned wells may have been affected by remote railroad systems. This observation appeared to

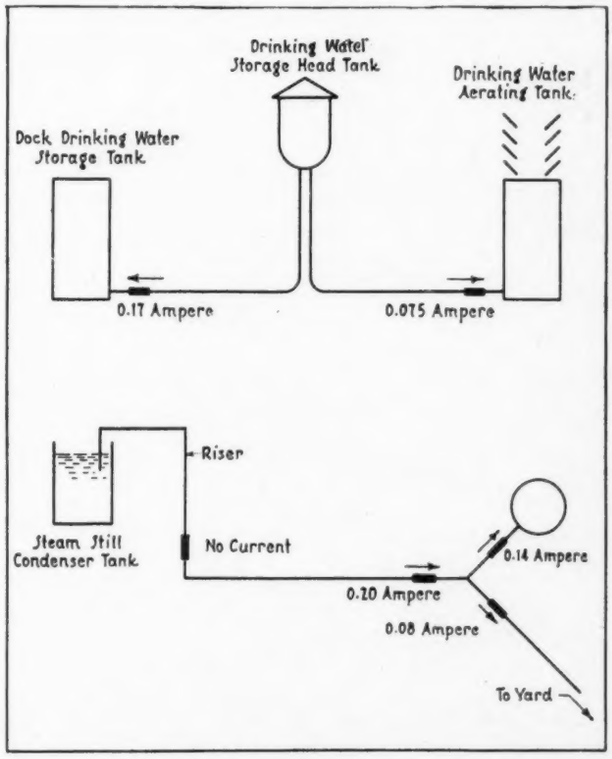


Fig. 4. Position of Wells in Relationship to Water Tanks Showing Direction of Current Flows.

be confirmed by readings obtained at the insulated joints. These data showed wide fluctuations over a short range and for short intervals of time. These fluctuations further indicated currents flowing at times into the plant and again away from it. The voltage readings were as high as 0.7 volts and the current as much as 50 milli-

[1]Proceedings of he American Institute of Electrical Engineers, June, 1912.

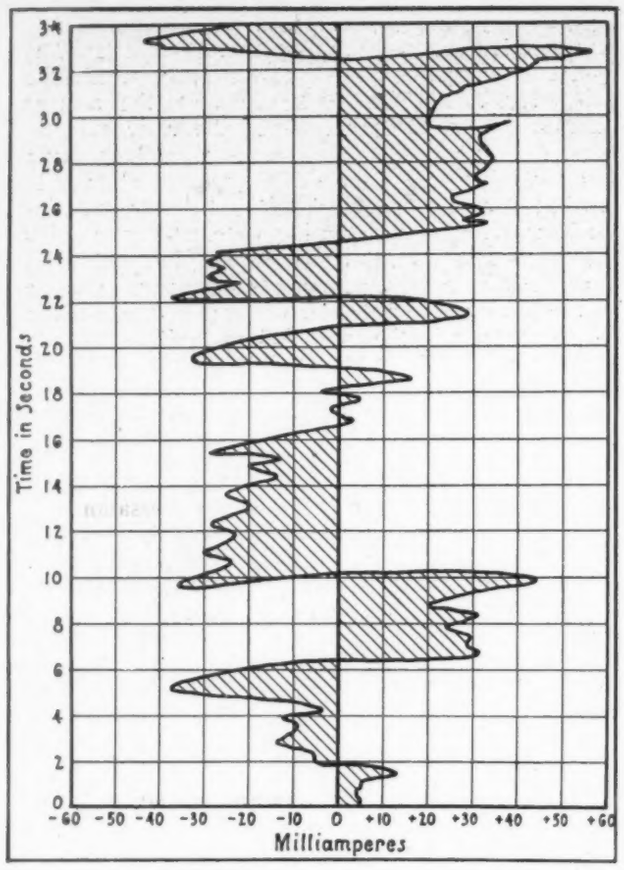


Fig. 5. Approximate Curve Showing Stray Current Fluctuation from Positive to Negative Values and Vice-Versa Over Short Periods of Time.

amperes. These data strongly indicate stray currents from the railroad.

Although the observations reported herein are not as definite and conclusive as was hoped, it seems quite probable that the corrosion of the well casings has been greatly accelerated by stray currents. These currents, passing through various strata of the earth, come in contact with the well casing and superimpose themselves on the steady static conditions, producing a voltage fluctuation observed. If these transfer currents do exist, although they are of a fluctuating nature, they may in time show their electrolytic effect at the points where they leave the casing or the pipelines and resume their travel towards their destination. We came to the same conclusions in our studies as that reached by Messrs. Burton McCollum and K. H. Logan,[2] namely, that—"the figures herewith presented, however, are sufficient to illustrate the point repeatedly emphasized in this paper, namely, that potential differences afford no measure of the intensity of current discharge from a pipe to earth, nor even of the polarity of a pipe with respect to earth." The results of the study were not as conclusive as desired, but for all practical purposes indicated at least a partial cause of the corrosion difficulty, in that electrolysis appears to have occurred.

It is quite possible to prevent currents from flowing into the well through the water line piping system by installing in these lines insulating joints and to eliminate insofar as possible, in the construction of the wells, contact between dissimilar metals; or, if it be necessary to have such construction, that these connections be properly insulated.

[2]Electrolysis Testing—By Burton McCollum and K. H. Logan. Technologic Paper No. 355.

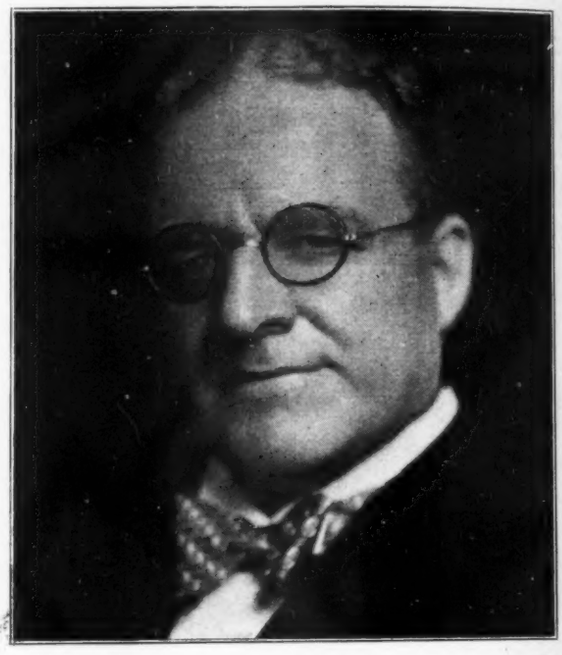
George Arthur Johnson

Colonel George A. Johnson, widely known authority on water works and sewerage, died of heart-failure on March 31, while at work after hours in his New York office. Those who knew him well will feel that he died as he would have wished—in harness. He was 59 years old.

In the water supply field, Colonel Johnson in early years made his mark. He began his career on the staff of George W. Fuller, during the operation of the Louisville Experimental Filter Station (1895), and in later years (1907-1910) he was a member of the consulting firm of Herring and Fuller.

In other locations he conducted studies similar to those at Louisville, and in 1903 assumed charge of operation of first modern type rapid sand filtration system in the United States—the plant at Little Falls, N. J., which served Paterson, Passaic and Montclair, N. J. In 1903 he also had charge of field investigations looking toward added sources of water for New York City, representing the beginning of the Ashokan Project.

His work on the purification of waters from the Chicago Drainage Canal is well known and there in 1908 as



George A. Johnson

partner in the firm of Herring and Fuller he employed bleaching powder to sterilize the water supplied to the stock yards. The same year he introduced the process to the Jersey City supply—markng the first American usage of chlorination as a means of purifying water for human consumption.

Colonel Johnson entered the U. S. Army in 1918, built up a special division for operating utilities. He retired in 1920, with the rank indicated, to reenter the consulting field.

He was a member of the American Water Works Association, American Society of Civil Engineers, American Public Health Association, New England Water Works Association and many other professional societies—the last named presenting him with the Dexter Brackett Medal.

Colonel Johnson was an excellent writer, with "The Typhoid Toll" and many other articles to his credit. At the time of his death he was serving as editor of "The Log"—the monthly magazine of the Circumnavigators Club of which he was at one time president.

THE INSTALLATION AND SERVICING OF POROUS AIR DIFFUSER MEDIUMS

By FRANK C. ROE

Sanitary Engineer, The Carborundum Co., Niagara Falls, N. Y.

TO maintain the high efficiency of porous diffuser plates and tubes of the type used for aeration in sewage and water treatment plants, their operation should be checked regularly. Partial clogging of the porous structure may occur for a number of reasons, thereby decreasing the effectiveness and increasing the cost of aeration.

The writer and his company have made a study of the various methods of servicing diffusers necessary to maintain their efficiency for a reasonable life. The publication of such information should be of value to those concerned with aeration by diffused air.

The most immediate and positive indication of obstruction within the diffuser structure is an increase of compressor or blower pressure necessary to supply a given quantity of air. Visual examination of the aeration tank or tanks will also disclose any non-uniformity of diffusion which may be due to a partially clogged condition. This is a practical determination but not so conclusive as the first.

Clogging of porous media is avoidable to a great extent. It is, therefore, proper to list the various sources of clogging, and the causes thereof, before discussing methods of cleaning. That trite old saying, "An ounce of prevention is worth a pound of cure," has a cogent application to this subject.

Sources of Diffuser Pore Obstruction and Methods of Prevention

Diffusers may become clogged on either the air side or on the liquor side; that is, on the top or bottom of plates and on the outside or inside of tubes. Both classes of clogging may be experienced simultaneously.

Liquor Side Clogging

1. *Suspended Solids:* Perhaps the most common type of clogging is caused by interruption of aeration during which the solids in water, sewage, sludge or mixed liquor settle and the water content filters through the diffusers into the air duct. Most of the solids in suspension are intercepted at the diffuser surface, but a definite proportion, depending on the pore size, will enter the top 1/16 to ⅛ inch of the structure. When aeration is resumed all of these particles will not be blown out of the structure and cumulative clogging results. Furthermore, some of the very fine solids which filter completely through the structure into the air duct may not be forced back through the diffuser when aeration is resumed, and additional clogging on the air side is possible.

Most of the sewage solids are organic and include grease, soap and stringy material as well as sludge. Frequently, however, inorganic solids, such as iron in the hydroxide form and carbonate of lime, are found in the top of the porous structure—the latter being most prevalent in hard water communities.

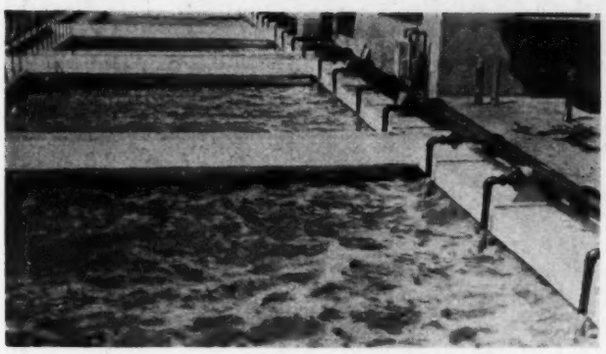


Plate 1—A Section of Aeration Tanks (Sewage Treatment Plant, Golden Gate Park, San Francisco), an Example of Uniform Diffusion

Maintenance of continuous air delivery is the positive way to eliminate this trouble. Temporary cessation of the air supply is not impossible with modern equipment, but the usual auxiliary blowers with standby power units and inexpensive automatic control equipment will largely eliminate shutdowns. As a suggestion along this line, gas engines operated on the gas from sludge digestion is one source of power not to be disregarded. They are giving satisfactory continuous service in a number of places where they are directly connected to blowers.

Care should also be taken not to over-design in the matter of diffuser area. Not less than one cubic foot of air per minute should be discharged per square foot of diffuser area. Insuring a higher rate, so as to maintain good air velocity through the pores as well as uniformity of diffusion from the entire diffuser area, is better practice still.

2. *Organic Growth:* Another form of liquor side clogging is growth of bacterial and protozoa life in the uppermost portion of the porous structure. This may be attributed, at least partially, to non-uniformity of diffusion. All of the diffusers controlled by a single valve may not have similar permeability ratings, or the individual areas of any particular diffuser plate or tube may not be uniform one with another. (Good and bad uniformity is illustrated in Plate 2.)

As suggested, it should be possible to avert clogging of this nature by careful installation and selection of plates or tubes. All units controlled by a single air valve should have a similar permeability rating within limits of 0.5 cu. ft. or less. Uniformity of individual diffusers depends upon precision and perfection in manufacturing.

3. *Miscellaneous:* Very often protection from cement grout (or other material used to install plates), dirt, debris, etc., is not provided during installation or when tanks are empty, and appreciable surface clogging results. A plate cover (see sketch) should be used to shield plates from cemening materials during installation, and other protective measures should be observed when tanks are empty.

Aid Side Clogging

1. *Dirt in Air:* Air containing a high quantity of soot or other impurities is a major source of clogging on the underside of diffuser plates or inside of diffuser tubes. Selection of effective air filters and care in locating the air intake are obvious preventatives.

The thought should be injected here that diffusers of higher permeability than the type used during the early days of sewage aeration are undoubtedly subject to less clogging of this nature because of relatively larger pores through which many of the fine suspended particles pass rather than stop. It is doubtful if the air bubbles released from higher permeability diffusers are very much

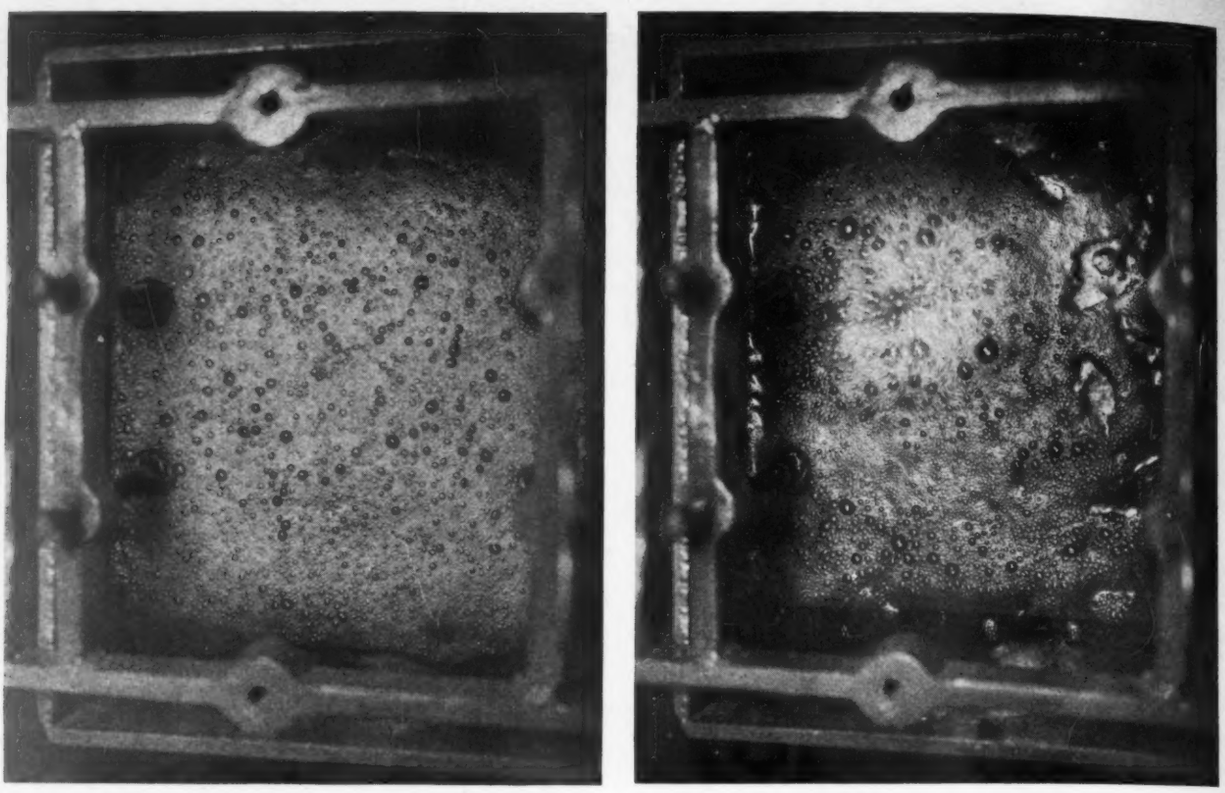


Plate 2—An Illustration of Good Uniformity of Diffusion on the Left; Poor Uniformity on the Right. (Photographs Taken Looking Down on Diffusion Plates in Testing Apparatus)

larger than the bubbles discharged from the earlier low permeability grade of diffuser. The theory advanced is that a certain buoyancy or bubble size is necessary to overcome surface tension and release the bubble from the diffuser surface, regardless of pore size. The fact remains that higher permeability diffusers have not been less effective than those of lower ratings previously specified.

2. *Oil in Air:* Reciprocating compressors are now rarely used in sewage aeration, but the oil which they force through air lines is responsible for pronounced diffuser pore plugging. Fortunately, the low pressure required for sewage aeration permits the use of rotary blowers of the centrifugal or positive displacement type. If reciprocating units must be used for any reason, an oil trap or filter of some kind should be used between the compressors and the diffusers.

Certain types of primary air filters depend on the use of an oil for cleanng or renovating. In this operation it is recommended that a partial wash with a solvent be given after the oil treatment so that oil will not be blown free and carried through the diffusers.

3. *Air Pipe Rust or Scale:* It is generally recognized that cast iron pipe as a material for air lines is sufficiently resistant to corrosion from moisture to be considered to have almost an endless life. Genuine wrought iron is likewise considered satisfactory. Galvanized or sherardized steel pipe would be considered suitable for relative short periods of life, while ordinary black iron pipe or steel is not suitable.

In spite of the consideration given to this phase of air pipe design, there is evidence that some air side clogging is caused by iron oxide in the form of rust particles and scale.

There are economic considerations involved in preventing this source of clogging. Aluminum and copper pipe have been used for the smaller air lines and are recommended along with other types of corrosion resistant pipe. However, if the use of such pipe raises the installation cost appreciably it should be balanced against the estimated cost of diffuser servicing and replacement, with attendant inefficiencies of aeration. The latter, however, is not very tangible when it comes to making such cost comparisons.

4. *Miscellaneous:* Air lines left in a dirty condition after installation can cause clogging of considerable magnitude. The remedy is obvious. Cast iron diffuser plate containers may cause the same difficulty as does iron piping, but to a lesser degree. Mr. William M. Piatt has avoided this possible source of trouble in designing containers for some of his plants in North Carolina, by using aluminum container linings. At other plants the entire plate holder is to be of aluminum.

Restoration of Diffuser Efficiencies

Because of the diversified types and degrees of clogging experienced in the 100-odd activated sludge plants in the country, it is natural to expect that there are many methods of cleaning in use. Lacking information on the subject, plant superintendents and operators have, more or less successfully, devised and developed individual methods of their own.

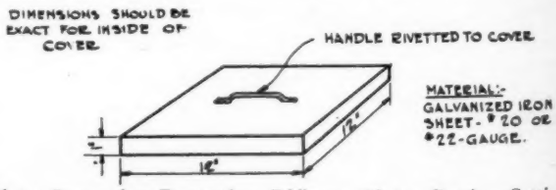

DIMENSIONS SHOULD BE EXACT FOR INSIDE OF COVER.
HANDLE RIVETTED TO COVER
MATERIAL:- GALVANIZED IRON SHEET- # 20 OR #22-GAUGE.
12"
16"

Plate Cover for Protecting Diffuser Plates During Setting

The writer's company, in addition to considerable experimental work in the research laboratories, has fostered a survey among those in charge of plants throughout the United States and Canada, believing that many practical methods of diffuser cleansing would come to light. The response to our inquiries and the cooperation received has been most gratifying and has made it possible to

present the outline to follow. Some of the methods have been improved, amplified or supplemented as the result of certain research work which we have conducted.

Methods employed in diffuser cleaning can be divided into two general classes; viz., methods applicable to diffusers in place (suitable largely to liquor side clogging) and methods which are adaptable only to removed diffusers. Tubes are cleaned for the most part by the latter method because they may be quickly and easily removed. The methods to follow are not given in an order to indicate preference.

Cleaning Diffusers in Place

1. *Caustic Treatment:* Clean aeration tank and surface of diffusers thoroughly with hose stream and leave about ½ in. of clean water over plates, providing the slowest practical air diffusion during this period. Dissolve about 1/10 lb. commercial lye crystals over each square foot of plate and then shut off air. Allow solution to penetrate plate (10 to 15 minutes), add more clean water, and then turn air on at maximum rate. (Note: This method is chiefly applicable to removal of organic compounds.)

2. *Sand Blasting:* Dry plates thoroughly by draining containers completely and blowing out porous structure with air applied at high rate. Sand blast plate surface with usual type of sand blast equipment, using "Blastite" Grain. Remove not more than 1/32 in. from surface, *maintaining maximum air discharge during the operation.* One minute or less is required to clean a plate by this method.

3. *Surface Spalling:* This method is applicable to diffuser plates of the silica type. Dry plates by draining containers and blowing out porous structure with air at high rate. Apply blow torch flame to entire top surface of plate until it cracks into flakes. Sweep off this film or scale and rub surface smooth with a Carborundum Brand rubbing block. Sweep off particles again. Leave air on during entire operation.

4. *Burning Out Surface.* Dry plates by draining containers and blowing out porous structure with air at high rate. With air off, saturate each plate with one quart of alcohol and apply heat with blow torch. Dry and brush off surface.

5. *Acid Washing and Scrubbing:* Dry plates by draining containers and blowing out porous structure with air at high rate. With air off, apply a 30 per cent solution of hydrochloric (muriatic) acid to the surface liberally and allow same to penetrate somewhat before turning on air at a low rate. Scrub with a stiff brush, using more acid if necessary. Follow with a clean water wash and scrubbing with a wire brush, continuing air discharge at a somewhat higher rate. (Note: This method is chiefly applicable to removal of inorganic compounds.)

6. *Vacuum Cleaning:* This method has not been proven but was suggested by authorities at the Milwaukee Sewage Treatment Plant, where a trial was intended. A vacuum pump was to have been used with a suction inlet of small area which would be held closely against and moved back and forth across the diffuser surface to be cleaned.

7. *Rest:* Dry plates by draining containers and blowing out porous structure with air at high rate. Allow diffusers to rest while dry for a week or more. (Note: The theory of this treatment is that the change of conditions will cause the bacterial and protozoa growth in the porous structure to die.)

8. *Chlorine Treatment:** Introduce a strong dose of chlorine into the branch air line leading to each diffuser assembly for several mintes during a low rate of air flow. Following by blowing out diffusers with the maximum possible rate of air flow. (Note: This method is chiefly applicable to removal of organic compounds.)

9. *Steam Backwashing:** Dry diffusers by draining and blowing out porous structure with air at high rate. Introduce steam into the branch air line at 10 lbs. pressure and scrub diffuser surface simultaneously with a stiff brush.

10. *Water Backwashing:** Introduce clean water into the branch air line under pressure of 15 to 20 lbs. per sq. in. Scrub diffuser surface simultaneously with a stiff brush.

*Methods applicable to tubes or plates and of some benefit also in cleaning the air side of diffusers.

Cleaning Removed Diffusers

11. *Acid Pickling:* Wash diffusers with water (use hose and brush). Set in a vertical position and allow to drain and dry as much as possible. Soak in 30 per cent solution of hydrochloric or nitric acid for four hours. See Plate 3. Wash with water. (Note: Use hydrochloric acid if it is desired to dissolve inorganic compounds and nitric acid if it is desired to oxidize organic compounds.)

Plate 3—Restoring Diffuser Efficiency by Pickling in Acid Bath—Method 11

12. *Caustic Treatment:* Place diffusers in vessel containing a 10 per cent solution of sodium hydroxide (lye) and boil for about one hour. Remove from this solution and wash thoroughly in boiling water. (Note: This method is only applicable to partial removal of organic compounds, chiefly fats, which are saponified by the caustic soda and then dissolved in hot water.)

13. *Sandblasting.* Dry diffusers thoroughly (preferably in an oven of some kind) and sandblast (Method 2) on either or both sides, as required. It is recommended that, where practicable, the diffuser be inserted in a container which will make it possible to force air through it at a high rate during the operation. This will eliminate any clogging by the dust created.

14. *Burning:* This method is applicable to diffusers of the fused crystalline alumina type. Place diffusers in a furnace or kiln in any convenient position, leaving a space of not less than ½ in. between units. (See Plate 4.)

Raise temperature gradually during 10 hours to about 1000 deg. Centigrade and then allow to cool gradually. The cycle should take at least 16 hours. Fuel of any kind is satisfactory, but care must be taken to avoid impingement of flame against diffuser surfaces. At Decatur, Ill., the gas from sludge digestion was used.

Selection of Method

Every plant operates under conditions peculiar to itself, which will prove a factor in the ease or difficulty of diffuser servicing and the methods of cleaning which can be, or should be, used. One method may work satisfactorily in one place but be wholly unsatisfactory in another place or at another time. Through experience each plant superintendent will find the most effective and economically feasible method of cleaning for adoption at his plant.

When serious clogging exists, all types of diffuser revivification are relative as compared to 100 per cent restoration of original permeability. In general, methods used on diffusers in place are not better than 75 per cent effective and range down to as low as 10 per cent where the clogging is almost wholly on the air side. Methods of cleaning removed diffusers are much more effective and are from 60 to 95 per cent effective. It is usually a combination of two or more methods which will produce the best result; because, any single method is not a cure-all.

The combination of causes and degree of clogging vary greatly and therefore it is not possible to give a rating of effectiveness to each method of restoration. It can be stated, however, that acid pickling of removed diffusers (Method 11) followed by burning in a furnace or kiln (Method 14) is 90 to 100 per cent effective, regardless of type of degree of pore plugging. This combination is, therefore, recommended where serious clogging exists.

Most of the methods described for use on diffusers cleaned in place are simple, not too expensive, and easily carried out at almost any plant without extra help. Special equipment becomes necessary when cleaning removed diffusers, particularly for the burning method. Like almost everything else that is "best," the burning or refiring method is probably the most expensive and is perhaps feasible only at larger plants.

A simple improvised furnace can usually be built at a sewage plant to refire diffusers, other considerations being satisfactory. (See Plate 4.) Where this work proves impracticable in the field, the writer's company will use its kilns at Niagara Falls for refiring when requested. Such arrangement would offer an added advantage in that refired diffusers can easily be retested and rated so that they may be properly re-installed thereafter.

The above suggests the consideration of providing a simple permeability testing apparatus at sewage treatment plants which would be useful in re-rating removed diffusers which have been cleaned at the plant. Even though original markings are retained, which is doubtful, all units will not respond equally to the cleaning method employed and will have a new permeability rating which should be determined when re-installation is made.

For acid pickling (Method 11) a wooden tub is satisfactory. The caustic treatment requires an iron kettle because of the boiling operation. Workmen should use precaution in these methods by wearing rubber gloves, aprons, etc. Tongs can be used to handle diffusers. (See Plate 3.)

Where existing plate containers do not permit simple mechanical plate removal, a joint composed of sand in the bottom ½ in. and cement grout in the top, is recommended for setting plates in holders. This will save time and avoid plate breakage when removal becomes necessary. Plates so installed should be set with a lime mortar under the supporting edges to insure an even bearing.

Conclusion

Maximum efficiency and life of air diffusers can be expected by installing the proper type of blowers, air filters, air piping, containers and appurtenances originally; and, by observing all precautionary measures as much as possible during operation.

The practice of regular servicing should be stressed if the diffusers in any plant are subject to a known source of clogging. If this is done, whether it is apparently needed or not, the permeability will be maintained indefinitely, in all probability, and one or more of the simple and least costly methods of revivification can be employed.

Because of the several potential sources of diffuser pore plugging which exist, and because many of these cause air side clogging, the use of plate containers which permit easy removal of plates is recommended. Ease of removal and replacement is one of the important advantages of diffuser tubes for smaller plants. (See Plate 1.)

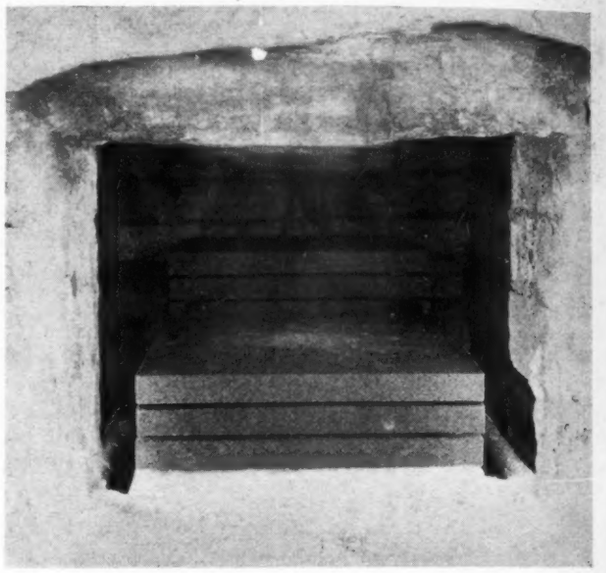


Plate 4—Diffuser Plates Stacked in Furnace for Burning-Out of Organic Matter. (More Clearance Between Plates Preferable; See Method 14)

Diffusers of high permeability are less subject to clogging because of larger pores. They operate on a slightly lower air pressure than low permeability diffusers. They are probably more easily cleaned when revivification is necessary. Because of these advantages, and the fact that effectiveness of aeration is not decreased (compared to that provided by low permeability diffusers), plates of a higher rating are recommended.

The writer wishes to express his appreciation to the several sewage works men who cooperated in supplying comments, data and information drawn from in the preparation of this article.

State Supreme Court Rules Municipal Revenue Bonds Constitutional

An important decision has been handed down by the Supreme Court of West Virginia which states that the act permitting municipalities to issue revenue bonds as security for funds borrowed from the federal government, for sewerage construction, is constitutional. A taxpayer's suit attacked the validity of a city ordinance which had provided for financing a self-liquidating utility (sewerage system) by issue of revenue bonds in accord with recent legislative acts, legalizing financing through issuance of this heretofore illegal form of municipal security.

PRACTICAL HYDRAULICS

I. The Sharp Crest Weir.

By P. S. WILSON

Consulting Engineer, Glen Ridge, N. J.

P. S. Wilson

THE so called Sharp Crest Weir is a very useful device for the measurement of water flowing in open channels or streams. A knowledge of the few simple rules governing the design and use of weirs will make it possible to measure the flow of water shed streams contributing to reservoirs, to estimate the overflow or leakage of dams and to make other measurements of use to the water works operator.

By a Weir is meant a bulkhead or dam over which the water flows, or more particularly, a notch in the top of such a structure through which the water flows. As shown in the illustration (Fig. 1), it usually consists of a rectangular notch and it is then known as a Rectangular Weir.

The Crest of a weir is the bottom of the notch, the level to which the water must rise before any can flow over. It is the edge or sill over which the water flows. A weir is a Sharp Crest Weir when the bottom edge of the notch, or the crest, is constructed so as to be as sharp as possible, flush with the upstream face of the dam, and with the opening beveled or enlarged on the downstream side so that the stream of water as it passes through the opening will only touch the crest along one sharp edge, as shown in Fig. 2. In the laboratory the crest is kept as sharp as a knife edge. In practice the edge of a metal plate or angle iron, as shown in the illustration, is usually satisfactory unless extreme accuracy is desired. The upstream face of the weir should be vertical, and of course the crest should be exactly horizontal.

The Head on a weir is the difference in elevation between the crest of the weir and the surface of the water in the pool upstream from the weir. With any given weir there is a fixed relation between the head and the amount of water being discharged, thus by measuring the head the discharge may be determined from the formula or table which applies to that particular form of weir in use.

The relation between the head and the discharge of a weir is different with different forms of crest and different shapes of notches. Different formulas must be used with such different weirs. The reason for making a weir sharp crested is that by so doing a weir can be built which can be used for the measurement of water without the necessity for making special tests to determine what the formula is. The formula for rectangular sharp crest weirs is known, and it has been found easier to reproduce standard conditions by the use of the sharp crest design than with most other forms. Most weirs built for the measurement of water are therefore constructed as sharp crest weirs.

Weir Formulas

One of the most commonly used formulas for use with rectangular sharp crest weirs is known as the Francis formula, named for its originator, Mr. J. B. Francis, who performed extensive experiments on weirs at Lowell, Mass., in 1851. This formula is as follows:

$$Q = 3.33 \times L \times h \times \sqrt{h}$$

In this formula:—

Q = Discharge of the weir in cubic feet per second.

L = Length of the weir crest in feet.

h = Head on the weir in feet.

$\sqrt{h}$ = The square root of the head in feet. The square root of the head is the number which, multiplied by itself, equals the head.

($h \times \sqrt{h}$ is often expressed as $h^{\frac{3}{2}}$, but it is more readily computed if considered in the form given above.)

Example: A sharp crest rectangular weir is 5.00 feet long and has a head of 0.42 feet (5 inches) on it.

(The square root of 0.42 is 0.65, because $0.65 \times 0.65 = 0.42$.)

$Q = 3.33 \times 5.00 \times 0.42 \times 0.65 = 4.55$ cu. ft. per second. The Francis formula given above is most accurate for heads between about 0.30 feet and 2.00 feet. A small error in determining the head makes such a large error in the discharge at very low heads, that for most practical purposes this formula is sufficiently accurate at all heads up to about 2.00 feet, and it is fairly accurate for higher heads also. The great advantage of the Francis formula is the fact that it is much simpler to compute than most of the others. The principal other formulas are known as the Bazin formula, the Fteley and Stearns formula and the Rehbock formula. A complete treatise may be referred to for the details of these other formulas.

This is the first of a series of articles by P. S. Wilson, prepared with the idea of presenting selected phases of hydraulics from the viewpoint of the practical water works operator.

The author, after graduation, continued his researches in the Hydraulics Laboratories of Cornell University, before taking up consulting practice as assistant to the late James H. Fuertes. He thereafter entered the water works operating field with the Community Water Service Company; became Superintendent of the New Rochelle Water Company and later Superintendent of Operations for the forty odd plants operated by the parent Company.

In 1932 he returned to consulting work, specializing in Water Works Management, and has served during the past year as Executive Secretary of the National Recovery Committee for Water Works Construction.

Mr. Wilson's experience enables him to contribute this series of articles which should be of genuinely practical value to Water Works Operators.—Editor.

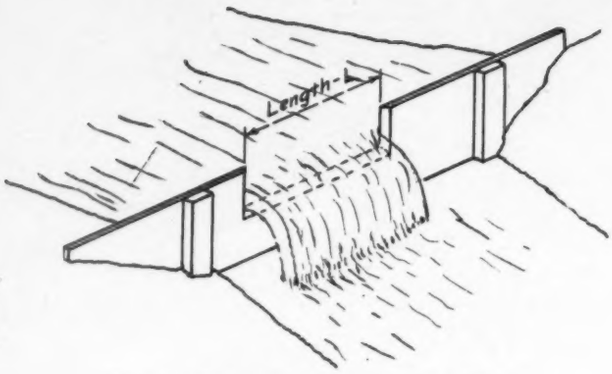


Fig. 1—Rectangular Sharp Crest Weir.

TABLE I—DISCHARGE OF A SHARP CREST WEIR PER FOOT OF LENGTH BY THE FRANCIS FORMULA

Head Expressed in Feet	Head Expressed in Inches	Discharge Per Foot of Length of Weir Expressed in Cubic Feet Per Second	Discharge Per Foot of Length of Weir Expressed in Gallons Per Minute
.01	⅛	.0033	1.5
.02	¼	.0094	4.2
.03	⅜	.0173	7.8
.04	½	.0266	11.9
.05	⅝	.0372	16.7
.06	¾	.049	22.0
.07	⅞	.062	27.7
.08	1	.075	33.8
.09	1⅛	.090	40.4
.10	1¼	.105	47.2
.12	1½	.138	62.
.14	1⅝	.175	78.
.16	1⅞	.213	96.
.18	2⅛	.254	114.
.20	2⅜	.298	134.
.22	2⅝	.344	155.
.24	2⅞	.392	176.
.26	3⅛	.441	198.
.28	3⅜	.49	222.
.30	3⅝	.55	246.
.32	3⅞	.60	271.
.34	4⅛	.66	296.
.36	4⅜	.72	323.
.38	4½	.78	350.
.40	4¾	.84	378.
.42	5	.91	407.
.44	5¼	.97	436.
.46	5½	1.04	467.
.48	5¾	1.11	497.
.50	6	1.18	530.
.55	6⅝	1.36	610.
.60	7¼	1.55	690.
.65	7¾	1.75	780.
.70	8⅜	1.95	870.
.75	9	2.16	970.
.80	9⅝	2.38	1070.
.85	10¼	2.61	1170.
.90	10¾	2.84	1270.
.95	11⅜	3.08	1380.
1.00	12	3.33	1500.

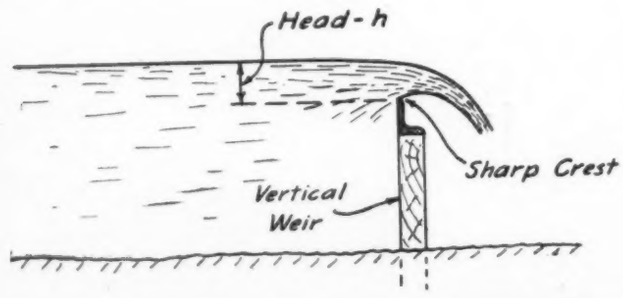


Fig. 2—Cross Section Rectangular Sharp Crest Weir.

For convenience the results of the computations from a weir formula may be arranged in a table, as shown in Table I. The discharge read from the table may be multiplied by the length (in feet) of any sharp crest weir to obtain the discharge.

There are several other features to be considered in the design and use of weirs and these will be discussed in subsequent articles. These will include particularly the correct design of the ends of the weir notch and the methods of measuring the head.

▼

Public Sewerage Systems of Germany

Reviewed by Abel Wolman

Public Sewerage Systems in Germany—By Prof. Dr.-Ing. E.h. J. Brix, Dr.-Ing. E.h. Karl Imhoff, Prof. Dr. R. Weldert. Two vols., 298 figures, 1549 pages text. Publisher Gustav Fisher, Jena, Germany. 1934.

The preparation of a comprehensive and authoritative compendium of the sewerage systems and sewage treatment plants in the United States has been frequently discussed. The vast amount of work involved in the collection and publication of the data, however, has so far deterred anyone from undertaking it.

While the task is under debate in this country, these two volumes from Germany give concrete demonstration of the fact that it can be done and when done is of inestimable value.

The work here reviewed represents a stupendous undertaking.

Detailed information on the sewerage facilities in all of the German cities is given in Volume 1, with a degree of detail varying with the size and complexity of the system. A brief description of the sewage treatment plant, of pumping stations, of the basis for design and of the costs, are included. In many instances maps and detailed drawings also appear.

Volume 2 contains the general principles underlying the design of public sewerage systems and of sewage treatment, figures on water consumption, the laboratory examination of sewage and sludge, and descriptions of administrative units for the control of sewerage systems and sewage treatment.

Detailed data on populations of the communities under discussion, on central control over sewerage programs, water consumption, lists of important patents, and a detailed bibliography are given ample space.

The books are packed with interesting, general and detailed information, which supply new reference volumes which we might well emulate for similar systems in this country.

The books are excellently printed and the paper is of fine quality. The authors are to be complimented on the accomplishment of a beautiful task.

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A.W.W.A. Exhibits to Be Beautified

Guy Northrup, Chairman of the Exhibit Committee of the A. W. W. A., may have let out a secret when he divulged the preparations under way to make the 1934 convention outshine all others in the matter of manufacturers' exhibits. A modern touch of beauty will be added to the instructive feature of the exhibits. The large ballroom of the Hotel Commodore is to be converted into an array of midnight-blue velvet and chromium which is to be employed in the modernized styling of booths and furnishings. Improving business, he says, will bring out a larger number of exhibitors and the location will make it possible for exhibitors to display a greater variety of equipment and materials than heretofore. Furthermore, there have been numerous items of new equipment developed which have never before been exhibited.

MEETING OF THE NEW JERSEY SEWAGE WORKS ASSOCIATION

THE New Jersey Sewage Works Association, the oldest sewage works association in America, held its 29th annual meeting on March 22nd and 23rd, at Trenton, N. J. In attendance (210 registered) it outranked the meeting of 1933. The annual "speechless dinner"—an innovation started some years ago by P. N. Daniels—went off without casualties or the singing of "How Dry We Are."

Officers elected or continued for 1934-35 were:

President—W. C. Mallalieu, Boonton, N. J.

1st Vice-President—Edward Highland, Moorestown, N. J.

2nd Vice-President—Edward P. Molitor, Springfield, N. J.

Treasurer—Paul Molitor, Jr., Morristown, N. J.

W. C. Mallalieu, Boonton, N. J., President of the Association

Courtland H. Shute, Glassboro, N. J., Retiring President

Secy. and Editor—John R. Downes, Bound Brook, N. J.

Technical Sessions

(President, C. H. Shute, presiding)

The following constitutes a digest of papers presented and discussion.

"Notes on the Operation of the Princeton Sewage Treatment Plant"—I. RUSSELL RIKER, Superintendent of Sewage Treatment, Princeton, N. J.

Mr. Riker described briefly the Princeton plant, which is of the separate sludge digestion-sprinkling filter type and named some of the operating troubles encountered, measures of correction employed and conclusions reached thereby.

He considered highly important the enforcement of an effective ordinance preventing abuses of the sewerage system by discharging therein substances deleterious to sewers or the treatment process. The new Princeton ordinance, he said, was based on experiences and practice in 30 municipalities having previously passed such ordinances.

As to plant operation; the primary settling tanks, having hopper bottoms but no sludge removal mechanism, had been difficult to keep clean. The digesters (sludge pH 7.2 to 8.4) had foamed even when the air temperature was 14 deg. below zero. Sludge dewatering (open sand beds) had been speeded up by additions of lime and iron coagulants. Filter fly breeding had been controlled by flooding the units each two weeks during summer. Sludge from the final settling tanks (no mechanism) had had to be drawn at least every week—preferably more frequently. The filter effluent contained 14 parts of nitrate nitrogen and was chlorinated at entrance of the final tanks, requiring 3.7 p.p.m. dosage to maintain 0.37 p.p.m. residual (avg.) at the outlet weir after 1 hour of settling. Control of odors had been one of the chief problems of summer operation,—smudge fires being used to indicate odor travel habits.

Prechlorination at the plant proper had been used to correct odors and required 9.6 p.p.m. average dosage for 9.6 hrs. (avg.) in hot weather. The already septic sewage, when chlorinated beyond the point of hydrogen sulphide destruction, had produced a medicated odor which close to the filters was rather objectionable. On this score a two point chlorine application had proven preferable. With low flows in dry hot weather the addition of brook water to the sewer to increase flow and freshen the sewage had been helpful in controlling odors and rendering prechlorination more satisfactory. Without such dilution, chlorine demands of the crude sewage as high as 32 p.p.m. (B.O.D. 428 p.p.m.) had been noted at times.

Mr. Riker quoted results of stream surveys, made prior to and since the plant had been placed in service, for the purpose of showing the extent of stream improvement noted. As to operating costs, the cost of pumping had averaged $11.50 per m.g. and treatment cost $23 per m.g. The cost had been high because of the plant under loading; and he estimated a cost for pumping and treatment at $25 per m.g. for the future.

"Notes on the Operation of the Little Falls Treatment Plant"—EDW. F. LAWLER, Superintendent of Sewerage, Little Falls, N. J.

Mr. Lawler, a believer in adequate operating records, showed as much by the carefully prepared graphs which he exhibited in the way of illustrating his review of the first year of operation of the separate sludge digestion-

Paul Molitor, Jr., Superintendent Sewage Treatment. Morristown, N. J. Elected Treasurer of the Association. Paul Is the True Son of the Father

John R. Downes, Bound Brook, N. J., Secretary of the Association and Editor of Proceedings. Watched Imhoff Tanks Foam; Got an Idea—in Fact, Several

sprinkling filter plant at Little Falls, N. J. The plant consists of bar screens; sedimentation tanks with sludge removal equipment; two circular sprinkling filters equipped with revolving distributors (operating on a minimum head of 9 inches); secondary settling tanks, glass covered sludge beds; a separate digester (consisting

of an old settling tank, equipped for heating and recirculation at inlet end with a floating cover over a section of the tank); chlorinators for pre- and post-chlorination. The digester arrangement had been unsatisfactory; was difficult to heat and to draw a satisfactory sludge and supernatant liquor from. Freezing around the edges of the floating cover had been another difficulty. The tank was to be revamped. Odors had been effectively controlled by prechlorination. The revolving distributors, except for drifting snow blockage of the arms, had given no difficulty. To avoid this difficulty he thought the 6-inch clearance between stone bed and the distributor arms should be increased.

Badly leaking sewers had been repaired as a C.W.A. project. Careful operating and cost records disclosed a total annual operating cost of $6,388—equivalent to $36.41 per m.g. or 53 cents per connection per month. The operating personnel had consisted of an operator, assistant operator and laborer. The operating cost was divided as follows: Salaries, 40.38%; extra labor, 8.78%; electric power, 21.48%; water, 7.6%; materials, repairs and supplies (except chlorine), 5.06%; chlorine, 15.6%. Of the latter only about half that purchased had been required because the flow had averaged only 179,200 gals. (119 gals. per capita) per day, whereas the plant had been designed for 875,000 g.p.d.

L. H. ENSLOW called attention to the satisfactory operation of revolving distributors in climates more severe than that of Little Falls. The infrequent operation of the distributors, due to existing flows being so far below design capacity, had apparently given the drifting snow an opportunity to accumulate and stop the distributors.

"Sludge as Fertilizer"—C. G. WIGLEY, Consulting Engineer, Atlantic City, N. J.

Mr. Wigley's paper put forth evidence of the value of dried sludge as a soil builder which, like animal manures, released its plant food over a period of years, and served as a source of humus. The results of the first year were most noticeable on leafy crops; the second year, on fruit and seed crops (peas, beans, etc.); on root crops, the third year. Air dried digested sludge (10 per cent water) would contain only about 2 per cent nitrogen. With 100 lbs. sulphate of ammonia; 200 lbs. of acid phosphate; 50 lbs. of muriate of potash added to 1,650 lbs. of dried sludge to produce a ton of product, the formula would yield a very satisfactory complete fertilizer with a carbon to nitrogen ratio of 6 instead of 8 for the sludge alone. Mr. Wigley referred to the use of a sludge shredder of the type being used at the Trenton plant which could be used for mixing and shredding at a single operation.

New Scheme of Sludge Drying

"A New Method of Sludge Drying"—JOHN R. DOWNES, Superintendent, Sewage Treatment, Plainfield-Joint Sewage Works, Bound Brook, N. J.

Mr. Downes* described the new mechanical sludge drying plant, installed by Industrial Associates, Inc., at the Plainfield (N. J.) works. He said the drier was very similar to successful installations in the industrial field for drying organic materials such as the production of soap or milk powder and the like. The digested sludge being first partially dewatered by a floatation process was fed by an adjustable rate Marlow diaphragm pump to the center of a rapidly revolving (adjustable speed) horizontal disc located at the center and near the top of a drying chamber. The wet sludge (90 per cent or less water) being thrown off from the revolving table as a spray, gave up its water while dropping (½ minute) to the bottom of the chamber through the heated (recirculated) air—therefrom, being mechanically removed as an odorless, fluffy material containing 25 per cent moisture or thereabouts. Forced circulation involved 13,000 cu. ft. of new air taken into the system per hour and the whole being heated to 900 deg. F., entered the top of the drying chamber and left at the bottom at 200 deg. F. Both inlet and outlet air temperatures were subject to automatic regulation to prevent scorching or underdrying. A coal burning drier furnace utilizing 400 lbs. of pulverized fuel per hour provided the heat at a predicted fuel cost of $3.30 per ton of finished fertilizer (25 tons of 90 per cent moisture sludge being converted to 3.3 tons of 25 per cent moisture fertilizer). Adding cost of chemicals for sludge floatation (thickening) and electric power, the total anticipated cost would be $6.50 per ton of finished product.

H. S. Vermilye, Superintendent of Sewerage, Tenafly, N. J. "Too Many Sewerage Coroners; Too Few Sewerage Doctors"

Gordon M. Fair, Professor, Sanitary Engineering, Harvard University, Cambridge, Mass. Osmoscopically Measures pO Values of Odors

Mr. Downes stressed the fact that the floatation scheme of lifting the digested or partially digested sludge to produce a scum at the top of the dewatering stand-pipe was a highly important part of the scheme. Production of economy in heat required and elimination of power for raising the sludge to the elevation required (lifted, instead, by the carbon dioxide gas liberated in the sludge) had resulted from adaptation of the principle of floatation—in fact, had been the secret of rendering the method practical as a sludge drying process. The variable speed diaphragm pump, thereby, served principally as a rate of flow and consistency regulator—performing a valuable function with little work. Watching Imhoff tanks foam had given him the idea of sludge lifting and thickening by the floatation scheme.

In reply to questions from the floor, Mr. Downes said that reinforcing chemicals to raise the fertilizer values of the dried product could be added, if desired, to the thickened sludge entering the drier. The minimum size of installation considered practical and economical to operate would appear to be that for a municipality with a population of 40,000. This conclusion was based on comparing all costs with that of plants with glass covered beds for sludge drying at increased rates on reduced areas. The cost for a plant serving 100,000 people or thereabouts would approximate 30 cents per capita; for larger plants, less. The moisture content of finished product would be maintained between 20 and 50 per cent—a matter to be decided on the basis of overall economy of operation. A product with even as much as 50 per cent water content was friable after squeezing a hand

*In an article to appear in a near future issue of WATER WORKS AND SEWERAGE Mr. Downes will fully describe the Plainfield sludge drying installation and operating results.—*Editor.*

full. Below 20 per cent moisture the product was dusty. The Plainfield unit would handle 10 gals. of thickened sludge (90 per cent moisture) per minute at an air recirculating rate of 30,000 cu. ft. per minute. Dust separation was provided for by a cyclone on the exhaust; automatic temperature control prevented odor nuisance from scorching the digested sludge.

Atmospheric Contamination by Sewage Works

"Measurements of Atmospheric Pollution by Sewage Works"—GORDON M. FAIR and W. F. WELLS, Harvard University, School of Sanitary Engineering, Cambridge, Mass.

Professor Fair presented a paper by himself and Mr. Wells which was of unusual interest, creative of con-

Floyd A. Hoffman, City Engineer, Morristown, N. J. Got Tired of Watching Sludge Bulk; Put In an Electric Eye to Do It for Him

Behind the Smoke-Screen Is "Chet" Wigley, C. E., of Atlantic City, N. J., Who as State Sanitary Engineer Organized the Association

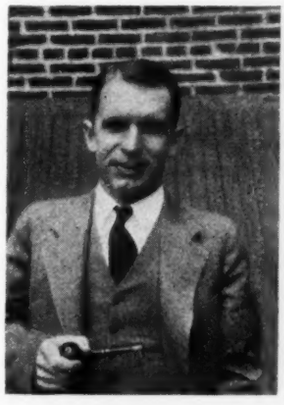
siderable favorable comment both as to contents and method of presentation.

Regardless of the arguments that there was no health hazard involved in aerial contamination by sewage works, Professor Fair said it behooved sewage men to do something about the more or less prevalent complaints of nuisance from odors or insects. Furthermore, a third possibility—bacterial contamination, entered the picture also. He and his co-workers, because of lack of practical methods of evaluating odors, had undertaken to make definite numerical measurements of odor values and intensities and bacterial density of the atmosphere at and near sewage treatment works. He called attention to the fact that, unlike heat or light, odors were created by particles of a substance without power of radiation. It was necessary, therefore, to have air currents to disseminate and carry odors to the nostrils. In addition, the evaluation of odors depended on intensity of concentration and usually there would not be a perceptible change in odor intensity until the dilution increase with odorless air had been as much as 60 per cent. A more practical consideration would be 100 per cent changes in dilution before noticing a lesser odor intensity by the human nose. Based on this fact the methods developed by himself and co-workers at Harvard University for evaluating odor intensity, had involved progressive dilutions of 1 volume of odorous air or liquid with an equal volume of clean air or liquid and increasing the dilutions progressively to obtain 1 to 4, 1 to 8, . . . 1 to 64, etc. The use of a simple sniffing device, dubbed the "Osmoscope," which had been devised to quickly evaluate odor intensities, was demonstrated by Professor Fair. By its use a pO value of 1, 2, 3, 4, etc., could be determined to indicate odor intensity just as pH values indicated acidity or alkalinity.

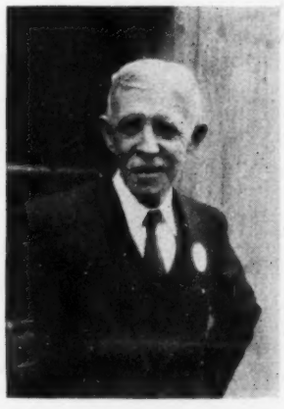
Indicative of the power of sludge gas to pollute the atmosphere, the pO value of sewages had been found to be 4 or 5, whereas the digester gases had started with a pO value of 15 and gradually diminished as digestion progressed. In thermophyllic sludge digestion (140 degrees) a pO value of 20 was common—requiring air dilution of 1 million to 1 to produce a threshold value of barely detectable odor.

Concerning the bacterial pollution of the air surrounding treatment works, Professor Fair said that recent tests had indicated that organisms of respiratory and skin diseases, thrown off in a mist produced when aerating sewage on sprinkling filters or by diffused air, could live a long time after evaporation of the moisture. Intestinal organisms were similarly thrown into the atmosphere but did not survive long. To determine the intensity of such bacterial pollution a special centrifuge had been constructed which made use of tubes coated with nutrient agar and eosine-methylene blue agar. As the air passed through the tube at a determined rate (volume) the centrifugal force caused the organisms to stick to the coating of media after which they were grown by the usual incubation and counted. B. Coli had been found in areas surrounding sprinkling filters and activated sludge plants. In a closed room in which sewage was being aerated by diffused air, b. coli to the extent of 7,200 per cubic foot of air had been found 35 ft. distant from the aerator. Professor Fair made it plain that no prediction as to the sanitary hazard of such contamination of the air was inferred but it was evident that such existed.

DR. W. RUDOLFS, in discussion, said that the methods developed at Harvard University should open up new opportunities to study hazards and nuisances from aerial pollution. He felt, however, that the fly nuisance must



A. E. Griffin, Research Department, Wallace & Tiernan Co., Newark, N. J. "Chief Odor Controller"



Bob ("Pop") Lindsay, Superintendent of Sewerage, Lynnhurst, N. J. One-Time Secretary of the Association; Has Never Missed a Meeting

be looked upon as a greater health hazard than that of aerial pollution by spray.

"Instruments and Methods Used in Detecting and Measuring Odors"—M. W. COWLES, Health Officer, Hackensack Water Company, Hackensack, N. J.

Mr. Cowles gave a demonstration of methods used in measuring odor intensities. He thought the use of the Osmoscope in conjunction with dilution employing odor free water or air had a sensitivity equal to the hot odor test of Standard Methods. The suggestion of utilization of a single nose piece had originated with Baylis in Chicago, the "threshold number" by progressively diluting originated with Spaulding of Springfield, Ill., and Professor Fair had gone a step further in evolving the Osmoscope and evaluating odors in terms of pO values.

In sewage treatment odor determinations would prove useful in plant control and particularly in evaluating odor control schemes. In tests conducted by himself, use of the Osmoscope had revealed a pO value of 4 before chlorinaton while following chlorination a slight chlorinous odor was detected even though no residual could be detected with orthotolidine. In making odor determinations with the Osmoscope agreement between individuals had been very close.

"Odor Control with Ferric Chloride"—A. E. GRIFFIN, Research Laboratories, Wallace and Tiernan Co., Newark, N. J.

Mr. Griffin, who had been recently working with the ferric-chloride process of odor control, successfully

Jonk Mick, Chief Operator, Essex Falls, N. J., Sewage Treatment Works—and a Good One; Enjoys a Convention

E. T. Killam, Associate, Alexander Potter, New York City. Spent Some Time in Atlanta; Showed Movies to Prove It—So Does This Snapshot

employed for the dual purpose of improved clarification and control of odors at Oklahoma City, Okla., and four other plants, reported that its chief advantage over chlorine lies in the fact that strong sewages required high chlorine dosages for odor prevention. Further, the dissipation of chlorine was rapid, leaving opportunity for re-innoculation of the sewage and secondary odor production unless more chlorine be applied.

The use of ferric-chloride for odor control was developed by Messrs. Scott and Darcey of Oklahoma City. There ferric-chloride made from chlorine and scrap iron in a concrete tower, had been applied to a trunk sewer receiving packing house wastes at a point about 3 miles ahead of the sewage treatment works, where the sewage was still fresh. The up-sewer application had been more effective than the use of chlorine alone in quantities greater than that required in producing ferric chloride required. According to chemical equations 3 pounds of ferric chloride ($FeCl_3$) would be required to convert 1 pound of hydrogen sulphide to ferrous sulphide (FeS). The explanation of the greater efficiency of ferric chloride, however, resided in the fact that all of the chlorine value could be accounted for in terms of the iron dissolved by it in the tower. This iron having no power to attack organic matter remained available during travel through the sewer to "grab" hydrogen sulphide as rapidly as produced until all of the iron had thus been converted to ferrous sulphide which, unlike hydrogen sulphide, is non-volatil.

Interestingly this same iron served as an aid in chemical precipitation practiced at the plant proper and it was therefore evident that the use of iron salts had potentialities in odor control conjointly with chemical precipitation or vice versa. Where sewages were strong and long sewers were involved the use of ferric chloride would probably supercede up-sewer chlorination in future odor control practice.

Asked if other iron salts might serve as well as ferric chloride, Mr. Griffin replied that he presumed they would.

Partial vs. Complete Chlorination of Sewages

"Effect of Partial Chlorination of Sewage in Bacterial Reductions"—DR. W. RUDOLFS, Director, New Jersey Sewage Experimental Station, New Brunswick, N. J.

Dr. Rudolfs reported on studies made to determine the degrees of disinfection procurable by partial satisfaction of the chlorine demand of sewages or effluents. This investigation had resulted from statements made at a previous meeting by Enslow and substantiated by Forman, to the effect that chlorination to 50 per cent of the total chlorine demand would produce b. coli destruction and disinfection efficiencies greater than 50 per cent and possibly as high as 90 per cent—the remaining 10 per cent of bacterial kill being far more difficult of attainment.

The findings as reported by Dr. Rudolfs, as an outcome of studies of effect varying of periods of contact (after adding the chlorine), and degree of disinfection (based on satisfaction of complete chlorine demand as representing 100 per cent chlorination) were in part approximately the following:

Per cent Chlorination	Contact	Per cent B. Coli Killed
40	7.5 min.	58.6
50	7.5 min.	70.0
60	7.5 min.	83.5
100*	7.5 min.	99.1*

*Residual Chlorine 0.2 p.p.m. or more.

Concerning effect of contact periods, the following represented minimum periods for securing a 95 per cent reduction of b. coli in fresh clarified sewages:

	Contact Required	Per cent Chlorination
(a)	2.5 min.	100*
(b)	15. min.	50
(c)	30. min.	40

*Residual Chlorine 0.2 p.p.m. or more

The data presented by Dr. Rudolfs were considerably in excess of the above used for illustration and served to justify the several following conclusions. In partial chlorination of settled sewage, contact time is highly important—not less than a 30 minute period being indicated. Chlorine should be quickly and effectively distributed for highest efficiencies and greatest economy. Chlorine is not selective to the extent that it does not destroy a high percentage of b. coli before the chlorine demand of the liquid and solids is satisfied. Both effects proceeded simultaneously but the disinfection effect was more pronounced than the chlorine absorption effect as one retrogresses from 100 per cent chlorination—i.e.—that required to satisfy the complete demand and leave a residual. With decreasing contact periods an increasing septicity of sewage, 100 per cent chlorination becomes more important. Chlorinated (substitution) products formed from proteins have a decided but slow or mild antiseptic value which increases with long contact periods. Chlorinated hydrocarbons lack in this respect as do products produced when very septic sewage is chlorinated—therefore, the earlier the chlorination the greater the chlorination effect with increased contact. On the whole there appeared to be no definite correlation between percentage of b. coli kill and percentage of chlorine demand satisfaction because of the varying qualities of sewage, effect of age (septicity or freshness) and completeness of suspended solids removal. In general, contact periods beyond 10 minutes were of added value in partial chlorination; with complete chlorination not necessary. To put it another way, with 10 minutes or less

contact all chlorine demand must be satisfied for high bacteriacidal efficiencies.

Dr. Rudolfs called attention to the forthcoming extensive report of the American Public Health Association on the Chlorination of Sewage, which had been prepared by a committee charged with compiling and evaluating the known facts concerning sewage chlorination practices. He understood that copies could be had from the Association or the Chlorine Institute.

L. H. ENSLOW said that the findings reported by Dr. Rudolfs and the conclusions reached were all in keeping with observation in practice, and thus, the preference, in general, for prechlorination over post-chlorination in order to reach the sewage in a fresher condition. Likewise, the practice was of especial value in procuring long contact periods and equalization of chlorination dosages at no additional construction cost for extended contact chambers. In the case of plants equipped with filters the recommended chlorination point for disinfection alone or improving stream condition was to the *inlet* end of the final tanks—just another form of prechlorination of effluents. The humus material from the filters had no chlorine demand to speak of—nor did it have a 24-hour oxygen demand, as a rule.

Symposium on Activated Sludge

"Some Notes and Comments on the Activated Sludge Process"—S. VERMILYE, Superintendent of Sewerage, Tenafly, N. J.

Mr. Vermilye, who is relatively a newcomer in the field of sewage treatment, presented a well received paper diagnosing much of the practical side of operation of any sewage treatment plant, but with particular emphasis on simplified control, which had been evolved at the first and only plant he had operated—the activated-sludge plant at Tenafly, N. J. Mr. Vermilye was given a rising vote of appreciation for his excellently prepared and presented paper.

Coming into the field as mechanical engineer, his first observation was that, in America as in England, the acticated sludge progress lacked standardization—there being many and varied opinions and practices involved. He had been impressed with the fact that there were many "Sewage Coroners" who knew that the patient had suffered and died, but there was a decided lack of "Sewage Doctors" who could diagnose the difficulties of the activated sludge process in time to save the ill patient. It was mostly a case of post-mortem after the process had gone bad, and voluminous laboratory work and records had not appeared to him to be worth the effort. Instead, he had come to the opinion, after some experience, that certain essential but simplified tests were sufficient for operation control at activated sludge plants. These included the residual chlorine test, methylene blue test, and tests to indicate the physical condition of the sludge and the quantities being carried in the aeration units.

Realization that there was a definite and an important relationship between the quantity and quality of returned sludge, air input and time, caused him to evolve an operation control scheme which would give him frequent pictures of plant conditions within 10 minutes after sampling without making gravimetric solids determinations. Samples collected hourly from the returned sludge line and every two hours from the inlet and outlet end of the aeration tanks, when centrifuged for 3 minutes for a sludge volume reading, had served admirably in plant operation control in maintaining a balance between changing sewage flow, air input, and sludge return. In addition, readings of depth of sludge blanket in the final tanks was made hourly during the day hours and less frequently at night. He believed that all activated sludge plants required 24-hour supervision. As to changes in sewage strength, no laboratory test was as capable of revealing important changes as was the effect on the process itself. He considered the resting or revivification effect procured during night hours, when loadings on the process were reduced, to be essential to the general well-being of the process.

As to parts of the plant, he had come to believe screening and grease separation, followed by some sedimentation ahead of aeration, to be important. He felt that rapid type filters on the end of the plant and ample metering devices to be worth the expense in every activated sludge plant. An amply valved plant was the dream of operators. As an aerating device, he believed that the use of porous tubes in combination with circulating paddles to be the most satisfactory. Well paid operators and a good by-pass around various units were other essentials to satisfactory and practical operation.

As a means of reducing operating costs, he had found that a 25 per cent saving in power bill could be had by taking advantage of off-peak power rates—having two meters instead of one for recording power takings. Instead of water, plant effluent had been used for operating chlorinators, flushing, etc., at a small pumping cost compared to the cost of water from the municipal supply. He advised every operator to see that his superiors were informed of the examination requirements involved in procuring their operator's license—by so doing, political interference was not apt to be so great.

In reply to a question, he said that there was no defined correlation between the solid test employing the centrifuge and the gravimetric determination. In general they were parallel, but a 20 per cent variation might be observed. The centrifugal test was made hourly for three points (returned sludge inlet and outlet of aeration tanks) between 8 A.M. and 4 P.M. and every 2 hours on the other shifts.

"Electric-Eye Control of Sludge Level and Sludge Return"—FLOYD A. HOFFMAN, City Engineer, Morristown, N. J.

Going Mr. Vermilye one better on his sludge blanket indicator, Mr. Hoffman described the adaptation of a photo-electric cell and electric light submerged in the final sludge settling tanks at Morristown for the purpose of automatically controlling the rate of sludge return and the sludge blanket depth in these units. Briefly stated, a rising sludge blanket obscures the light and the photo-electric cell automatically starts a return-sludge pump which operates until the light is again exposed due to lowered sludge blanket. The scheme has proved very effective at the Morristown plant and a model of the device on display during the meeting created considerable interest. (This novel device and its operation will be more adequately described in an article by Mr. Hoffman which is to appear in a near future issue of WATER WORKS AND SEWERAGE.—Editor.)

WESTON GAVETT, Consulting Engineer, New York City, said that 24-hour supervision at activated sludge plants was not in his opinion necessary. Devices such as that described by Mr. Hoffman would simplify operation, make continuous supervision less necessary than now considered, and otherwise reduce operating costs.

"Some Bio-Chemical Indices of the Condition of Activated Sludge"—H. HEUKELEKIAN, New Jersey Experimental Sewage Station, New Brunswick, N. J.

In determining the quality or condition of activated sludge, Mr. Heukelekian said that the settling rate and color of sludge had been the most common tests applied. Also, the settling "index" (volume per unit weight of sludge on the dry basis) had also been used by some as an indication of sludge condition—the lower the index

the better the condition. There, however, was a lack of correlation between plant performance and these tests. An earthy odor usually accompanied a good sludge, and the color was brownish, but not always. Concerning the bacterial population, there seemed to be a correlation, indicating that efficiencies and conditions suffered with increasing numbers of bacteria per milligram of dry solids. During such changes there was not a noticeable difference in numbers of bacteria per c.c. of sludge liquor. For example, a plant yielding 82.8 per cent efficiency had 47.4 million bacteria per mgm. sludge solids; another yielding 90.4 per cent efficiency had only 8.3 million per mgm. The poorer sludge also contained a greater variety of species than the better. At the same time small protozoan forms had predominated in the poor sludge (156 per mgm.), whereas the large forms predominated in the good sludge (9.1 per mgm.). In the marked change of bacteria and protozoan population the break had come at 1500 p.p.m. suspended solids content.

The B.O.D. index $\left(\frac{\text{B.O.D.}}{\text{P.P.M. Solids}}\right)$ had shown that a demand of 0.3 lb. of oxygen per pound of solids was indicative of good sludge. For a quick indication the oxygen consumed test (digestion for 1 hour with acid permanganate solution) might prove useful. The oxygen consumed index $\left(\frac{\text{O.C.}}{\text{P.P.M. Solids}}\right)$ indicative of good sludge seemed to be between 0.36 and 0.38. Nitrate and nitrite content of sludge liquor seemed to be of little value as an index of efficiency, and the same could be said of the dissolved oxygen content, provided, however, at least some was present. Dr. Heukelekian thought that solving the mysteries of the sludge proper should prove of great value in any fundamental study of the activated sludge process.

"Comparing the Efficiency of Various Mechanical Aerating Devices"—I. O. Lacy, New Jersey Experimental Sewage Station, New Brunswick, N. J.

In a series of tests, employing small models, an attempt had been made to evaluate the efficiency of four mechanical aerating devices. The biological condition of the sludges produced had been about the same as that produced by diffused air aeration. Of the devices employed (Link-Belt [Straight Line] Aerator, Simplex, Dorr [Turbo] Aerator, and the Revolving Brush Aerator) all had been capable of producing satisfactory results. The highest B.O.D. reduction during 6-hour aeration had been 97 per cent for the Turbo Aerator—the lowest (89 per cent) for the Brush Aerator. The Link-Belt mechanism had yielded 93.5 per cent and the Simplex 92 per cent reduction. After 16 hours aeration all yielded about the same—96 to 97 per cent.

Motion Pictures Close the Meeting

Following the technical papers, Stanton L. Dorsey, Consulting Engineer, Washington, D. C., showed several reels of motion pictures he had taken of sewage treatment works while in Germany.

E. T. Killam, Consulting Engineer, with Alexander Potter, New York City, explained the chemical precipitation plant constructed and operated for several months at Atlanta, Ga., under his supervision. His talk was illustrated by moving pictures—the colored reel being particularly impressive in showing the floc formation, rate of settling, sludge condition, clarity of effluent, and condition of Peachtree Creek. Mr. Killam said that a fair statement of average results would be removals of 86 per cent suspended solids and 71 per cent 5-day B.O.D. value by coagulation and sedimentation. With rapid filtration of the precipitation tank effluent through an anthracite coal filter at rates of 4 to 5 gals. per sq. ft. per minute, the removals had been increased to 97 per cent suspended solids and 81 per cent B.O.D. Chemical dosages for such removals averaged 44 lbs. ferric chloride ($FeCl_3$); 770 lbs. of burnt lime and 192 lbs. of ferrous sulphate (copperas).

Manufacturers Well Represented

The following manufacturers had exhibits of equipment or materials: American Brass Co.; Armor Fence Co.; Bailey Meter Co.; Brick Manufacturers Association; Carborundum Co.; Chain Belt Co.; Dorr Co.; Fairbanks, Morse Co.; General Electric Co.; W. and L. E. Gurley; Hardinge Co.; Homelite Pump Corp.; Link-Belt Co.; A. S. Marlow; Norton Co.; Pacific Flush Tank Co.; Pennsylvania Salt Mfg. Co.; Phipps and Bird; Row Engineers; Royer Co.; Arthur H. Thomas Co.; Wallace and Tiernan.

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Walter M. Bell, Killed in Airplane Accident

Walter M. Bell, who had but recently resigned his position with the Sanitary District of Chicago, which he had served as Superintendent of its Northside Sewage Treatment Plant since 1928, to join the Sanitary Division of the Jeffrey Manufacturing Company, was killed in an airplane wreck in Illinois on March 6, while on a business trip.

Mr. Bell, born in Ashley, O., took courses in Mechanical Engineering at Ohio State University; left to serve in the Chemical Warfare Service during the war; became Plant Superintendent at Edgewood Arsenal. He later accepted a position with the Frick Company—resigning to enter the employ of the Sanitary District of Chicago. He was only 37 years old at the time of his untimely death; leaves a father, mother and wife.

▼

Laundry Strike Settled by Water Department

A novel method of stopping a strike and forcing N.R.A. minimum wage compliance by laundry owners, was applied in New York City by the Water Department. Laundries which had refused to meet the demands of strikers, for the minimum wage of 30 cents per hour, could not be prevailed upon by authorities of the Regional Labor Board to comply with the wage law.

Mayor La Guardia thought of a method to "crack-down" on these laundry owners which proved an effective one. The water supply was ordered cut off. There being nothing much more helpless than a laundry without water, the strike breakers were dismissed and the minimum wage was offered employees out on strike. In addition, the mayor learned that one laundry owed the water department $20,000 in unpaid water rent, another $17,000.

▼

CWA Water and Sewerage Projects in New York State

During the past two months there has been considerable activity in improvements to and extensions of water supply systems, reconstruction and extension of sewers, drainage of lands to prevent floods and to control mosquito breeding, and many other diversified works of a sanitary nature. The unusual opportunity of obtaining the entire cost of labor from the Federal Government under the Civil Works Administration is responsible for these activities at the present time.

Out of a total of about 3700 projects which were approved by the CWA during December, over 500, or about 13 per cent, were for sanitary improvements.

A STUDY OF FILTERING MATERIALS FOR RAPID SAND FILTERS

By JOHN R. BAYLIS*

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This is the first of a series of articles by Mr. Baylis which will deal with the subject, "Filter Materials for Rapid Sand Filters."

The second will describe a new method of determining the effective size of filter materials, which appears to the author to have merit. The third will discuss various filtering materials from the standpoint of the merits and shortcomings of each. The final article of the series will set forth specifications for filter sand and other filtering materials, based on the experience of the author.—Editor.

PART 1.

WE have seen several interesting phases of water treatment develop and receive much attention within the past 30 years, yet very little has been said about the filter bed. Perhaps it is now due to receive more consideration than it has in the past. Very few believe that silica sand will be replaced in filter beds to any great extent with some other material, or by some form of filtration which does not require sand, consequently it is not likely that investigations of the sand bed or of filtering materials in general will create as much interest as has been the case for some of the other developments in water treatment.

Several have recently investigated the flow of water through sand, and while this is largely of technical interest at the present time, it is attracting attention to the filter bed, which is worth a great deal. A few already have formed the opinion that filtration has been reduced to a more scientific basis, or to mathematical computation. How much of value will result from these investigations, it is too soon to state. Perhaps out of the mass of data which is being produced by various workers, there will result a better understanding of the performance of filter beds, and the influence, size, shape and character of the filtering materials have upon filtration.

It is the purpose of this article to review briefly what has been done in the past on filtering materials, and to give some of the main facts brought out by a study of such materials which has been under way for the past several years. Any investigation of filtering materials of value is quite complicated, requires considerable equipment and also requires much research work to be carried on over long periods of time.

Historical

The Work of Hazen on Determining Sand Size.—The use of sand for removing suspended matter from water dates back many years, and while the first municipal filtration plant was constructed at London in 1829, sand filtration was known before this. Classification of filtering materials according to size apparently received little attention prior to the establishment of the experimental station at Lawrence, Mass. In the 1892 Annual Report of the Massachusetts State Board of Health, Hazen[1] published his method of sand analysis. This method proved so valuable it was immediately adopted for analyzing filter sand and has been used with very little change up to the present time.

Hazen's method of determining sand size by sieving was for slow sand filters and was not intended for rapid sand filters, yet it was soon adopted for analyzing sand used for both types of filters. It was adopted largely because of its simplicity and for lack of a better method, also for the fact that it enables one to specify sand which is fairly satisfactory for rapid sand filters. The method is one of determining the amount of the sand which ranges in size between screen openings of known size; that is, it is the material which is retained on a certain sieve after passing the sieve next larger in size. This method of determining the size of the sand probably will continue to be used, though certain modifications of the method to give more accurate information about the material may be made.

The use of crushed materials to a limited extent in filtration now makes it necessary to take into consideration the shape of the material as well as the size determined by sieves. Hazen's method of determining the sand size by sieves did not take into consideration the shape of the grain, though he[2] gave a method of determining sand size with the microscope which did take this into consideration. In this method the three diameters of the grain were measured.

From the sieve analysis, or measurement by the microscope, the suitability of the material for filtration purposes is determined. It is in computing the performance of filtering materials from the sizes which have been determined by one or the other procedures mentioned where we may expect modifications of customary practice. There is very good evidence that Hazen's method is still satisfactory for determining the size of sand for slow sand filters.

The Hazen Method of Sieving.—Briefly the Hazen sieving method is to dry a representative portion of the sand, weighing out about 100 to 200 grams of the sample, sieve through screens made of brass wire having, as near as possible, square and even-sized meshes. The weight retained on each sieve after shaking is determined and computed in terms of the entire sample. It is customary to determine the total percentage which will pass each sieve, which is the sum of all of the sieve portions of finer size. The sieve sizes are plotted against percentage passing, and the 10 and 60 per cent sizes are determined. The 10 per cent size is called the *effective size;* that is the size of which 10 per cent by weight is finer or of lesser diameter. The *uniformity coefficient* is a term to designate the ratio of the size of grain which has 10 per cent finer than itself. Hazen calibrated the sieve openings by determining the size of the largest sand grains passing the sieve. The weight of the largest size sand grains give spheres which have diameters slightly larger than the size of the sieve opening, due to most of the grains being elongated and not perfect spheres.

Hazen's Microscopical Method.—"The size of the sand-grain is uniformly taken as the diameter of a sphere of equal volume, regardless of its shape. As a result of numerous measurements of grains of Lawrence sands, it is found that when the diameter, as given above, is 1, the three axes of the grains, selecting the longest possible

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and taking the other two at right angles to it, are, on an average, 1.38, 1.05 and 0.69, respectively, and the mean diameter is equal to the cube root of their product." Hazen found that the middle diameter was approximately the same as the mean diameter. The writer has made a number of microscopical measurements of sands and finds for natural sands the ratios to be near that given by Hazen.

About the only modification which has been made in the original sieving method adopted by Hazen is to use more sieves so that the sieve sizes will be closer together, and to shape the samples longer in shaking machines.

In addition to working out a method of determining the size of the sand grains, Hazen[2] gave an equation for computing the flow of water through sand beds. This will be discussed later.

Suggested Modifications of the Hazen Method.—In 1915, Burgess[3] recommended changing the standard of measurement from the size of the sand grains as given by Hazen to the size of opening in sieves, stating that sieves could be obtained which are composed of wires of uniform sizes and of accurate spacings. Burgess found the average ratio of size of separation to size of opening to be 1.10 for the coarser sieves and 1.18 for the finer sieves made of twilled cloth. Hazen did not give any definite size ratio in his original article published in 1892, but stated: "The size of separation of a sieve bears a tolerably definite relation to the size of the mesh, but the relation is not to be depended upon, owing to the irregularities in the meshes and also to the fact that the finer sieves are woven on a different pattern from the coarser ones, and the particles passing the finer sieves are somewhat larger in proportion to the mesh than is the case with the coarser sieves. For these reasons the size of the sand-grains are determined by actual measurement, regardless of the size of the mesh of the sieve."

Burgess also suggested doing away with the term "Effective Size" and substituting in specifications that 10 per cent of the sand shall pass a certain sieve number, or a sieve having a certain size opening. Hazen, in discussing the article, made such a good defense of his method that little effort was made to adopt the suggested change. He stated comparative studies showed that if 8 per cent was taken as the limit instead of 10 per cent, too much weight was given to the effect of the finer material, and if 12 per cent was taken, the effect of the finer material was inadequately represented. The Lawrence data were very clear upon this point, and the 10 per cent limit was selected because it brought all the materials for which data were then available into their correct relative position with respect to frictional resistance and capillarity. Hazen stated that there is no reason to suppose that 10 per cent is a precise mathematical limit always true to all materials. He also stated that Mr. Burgess evidently overlooked the fact that all the earlier specifications for sand and gravel drawn in his (Hazen's) office were drawn in the way proposed by Burgess. The Albany filter specifications required that, "The grains . . . shall be of the following diameters: not more than 1 per cent by weight shall be less than 0.13 mm. nor more than 10 per cent shall be less than 0.27 mm., at least 10 per cent by weight shall be less than 0.36 mm. and at least 70 per cent shall be less than 1.0 mm. No particles shall be more than 5.0 mm. diameter."

A Surface Modulus for Filter Sand.—In 1915, Professor Tyler[4] suggested the use of a surface modulus for filter sand, stating that the chief objection to the Hazen method was that it fixed only two points on the graph representing the sieve analysis. The surface modulus was found by the equation

$$S = P_1 + \frac{P_2}{2} + \frac{P_3}{4} + \frac{P_4}{8} + \frac{P_5}{16} + \frac{P_6}{32} + \frac{P_7}{64}$$

P_1 = Percentage passing the No. 100 sieve.
P_2 = Percentage between 100 and 48 mesh sieves.
P_3 = Percentage between 40 and 28 mesh sieves.
etc.

Tyler gave the equation $h = 0.000_{99}\ S^{2.25} \times Q$ for the loss of head through the sand bed.

h = Loss of head in feet per foot of depth of bed.
S = Surface modulus.
Q = Discharge in gallons per square foot per minute.

The equation was based on a temperature of 72 degrees F., and no temperature factor was given. Tyler claimed the surface modullus method was somewhat more accurate than the Hazen method. The article does not state if the surface modulus was intended for use on rapid sand filters, but apparently not, for the tests were conducted in a manner which would not be expected to give accurate results for such filters. So far as is known no attempts have been made to use the method in filter work.

Report of the Committee on Filtering Materials, 1925—A very valuable contribution on the study of filtering materials was given in the 1925 "Progress Report of Committee No. 18, on Filter Sand Testing and Recording," Paul Hansen, Chairman.[5] A brief abstract of the main parts of the report will be given. Fifty samples of sand were sent to various people for analysis, and 29 replies were received. No definite procedure can be laid down for sampling sand at its source, but emphasis should be placed on the necessity of getting a fair and representative sample. The sample taken should be quartered down until a suitable amount has been obtained for sieve analysis. It should be dried at a temperature not to exceed 100° C. The committee does not believe that standardization of sieves is in a sufficiently satisfactory state to recommend them for the analysis of filter sands without calibration of the sieves as called for in the Hazen method. A set of sieves with openings varying in the ratio of the square root of two is satisfactory. It is probable that twilled wire will have to be used for the fine screens at present, but as soon as manufacturers can meet the requirement only double crimped wire should be used.

The committee found that calibration of sieves by the users was frequently neglected. The quantity of sand used in making a sieve analysis does not appear to be important, though it is believed well to stipulate approximately 100 grams. Hand shaking appears to give as reliable results as machine shaking, and unless some particular make of shaking machine is adopted, hand shaking should be permitted as a part of standard procedure. A rocking motion consisting of 200 rocks (a complete motion back and forth is considered one rock) is recommended. Machine shakers should not be ruled out, but they should be so operated as to give essentially the same results as are obtained by the hand rocking motion. Nearly all of those reporting to the committee expressed results in "effective size" and "uniformity coefficient." The suggestion by Baylis that the term "fine ratio" (the fine ratio is the ratio between that size which 1 per cent is finer than and that size which 10 per cent is finer than) also be used as elements of merit, but it did not appear to the committee that the time has yet arrived for making a definite decision in favor of it. It makes little difference what kind of paper is used for plotting, though some uniform type of plotting should be used. "Probability paper" appears to be the best.

Additional Work on Sand Sieving.—Mahlie[6] gave the results of sieve analyses of sand samples collected in different manners. The "grab sample" was taken by picking up small portions of the sand from different parts of the filter bed before the filter had been washed. The "core samples after first washing" were taken by forcing a piece of 2-inch copper pipe about 4 feet long down into the sand. The tests showed that the grab samples and the core samples were in fairly close agreement. Neither the midway sample nor a sample taken 6 inches below the surface give a representative sample of the entire bed.

In the 1926 Report of Committee 18 on Sand Testing and Recording[7] specifications for sieves were discussed. The committee states: "If tolerances in diameter of sieve opening and wire diameters can be kept within proper bounds, in other words, if one can rely on obtaining testing sieves of a satisfactory degree of uniformity, then it would be permissible to make comparison of sand on the basis of sieve opening rather than on the basis of mean diameter of the largest sand grains passing given sieves. For the time being, however, it would be desirable to multiply the separations as indicated by sieve openings by 1.1, which will give approximately the mean diameter of the largest sand grains passing given sieves. This factor is a variable one, depending on the shape of the sand grains and on sieve openings, but for ordinary separations used in filter sand analysis, variations in the factor would probably not be more than about 6 or 7 per cent." The Committee did not recommend the use of uncalibrated sieves. It stated that the terms effective size and uniformity coefficient are relatively meaningless when applied to the bed as a whole and that there was belief among a number of the Committee that the terms should either be discarded or their definition revised.

Measurement of Sand Size with the Microscope.—As an appendix to the Report of the Committee on Filtering Materials in 1932, the writer gave a method of measuring sand size with the microscope. The shortest diameters of the sand grains as they laid spread out on a Rafter's counting cell were taken as the diameters of a sphere of equal volumes. The size determined in this manner was slightly larger, though very close to that determined by the sieve method. The writer did not recommend the use of the microscope for determining the size of the sand, except where the grains contained a coating which might be rubbed off by drying and sieving. This was largely on account of the time required to make a measurement with the microscope.

Investigations on the Low Flow of Water Through Sand

The Hazen Equation.—Hazen[2] states that the frictional resistance of sand to water when closely packed, with the pores completely filled with water and in the entire absence of clogging, was found to be expressed by the equation

$$v = cd^2 \frac{h}{l} \frac{(t+10)}{60}$$

v is the velocity of the water in meters daily in a solid column of the same area as that of the sand.
c is an approximately constant factor.
d is the effective size of the sand grain in millimeters.
h is the loss of head.
l is the thickness of the sand through which the water passes.
t is the temperature of the water (Fahr.).

Hazen stated that the value of c may be as high as 1200 for very uniform and perfectly clean sand, and may be as low as 400 for very closely packed sands containing a good deal of alumina or iron.

The friction of the surface layer of a filter is often greater than that of all the sand bed below. It must be separately computed and added to the resistance computed by the equation. In measuring the loss of head through the sand for use in the equation, Hazen took one column of water from the filter two or three inches below the surface of the sand and another column at the bottom of the sand bed. In this manner the friction through the top two or three inches was not taken into consideration in the equation.

Hulbert and Feben Equation.—Hulbert and Feben[9] investigated the flow of water through sand and developed an equation somewhat like the one given by Hazen, except instead of using one constant to take into account several factors, a porosity coefficient was added. Their equation is

$$l = \frac{}{} \left\{ \frac{dr\ (73 - p)}{S^{1.89}\ (t + 20.6)} \right\}$$

l = Loss of head in feet.
d = Depth of sand in inches.
r = Rate of flow in m.g.a.d.
p = Porosity.
S = Sand size in mms. (50 per cent or median sieve size).
t = Temperature of the water in degrees F.

One noticeable difference between this equation and the one developed by Hazen is that the loss of head varies as the 1.89 power of the diameter instead of the diameter squared. Also there is a difference in the temperature factor. The Hulbert and Feben equation should give results slightly more accurate than the Hazen equation, though the Hazen equation appears to be all right for practical uses, providing the right constant is selected. It is not easy, however, to select the right constant without making actual tests.

Fancher and Lewis Equation.—Fancher and Lewis[10] conducted experiments on the flow of oil, water and air through porous materials. When they plotted Fanning's equation against the modulus dUP/μ there was a fairly consistent relation in the results. The Fanning equation is

$$f = \frac{gd\Delta p}{2\ PLU^2}$$

f = Friction factor.
g = 32.2 feet per second.
d = Diameter of average grain in feet.
p = Pressure drop, pounds per square foot.
ρ = Fluid density, pounds per cubic foot.
u = Apparent velocity, Q/AP, ft. per second.
U = Apparent velocity, rate of flow divided by cross-sectional area, Q/A, feet per second.
μ = Absolute viscosity, 0.000672 z, pounds per second per foot. z = Absolute viscosity at temperature of flow, centipoises.
P = Fractional porosity (effective), (volume of connected pores)/(bulk volume of sample).

The average diameter was calculated from the screen analysis by the formula:

$$d = \sqrt[3]{\frac{\Sigma\ n\ d_s^3}{\Sigma\ n}}$$

n = Number of grains per gram of material for any average diameter of opening d_s.
d_s = Average diameter of opening. The sum of the two sieve openings divided by two.

Fancher and Lewis found excellent correlation and alignment of the data for unconsolidated sands when

plotted on logarithmic paper. They state that: "Clearly, the evidence is that the flow of fluids through sands and other unconsolidated solids resembles the flow of fluids in pipes, and that the same laws of hydro-dynamics may be applied as far as our knowledge of the effect of the various related factors which control permits."

Fair and Hatch Equation.—Fair and Hatch[11] developed an equation for the flow of water through sand also based upon the stream-line flow of water through pipes. The equation for a stratified sand bed is

$$H = KLTFv \frac{S^2}{100} \left\{ \text{Sum of } \frac{P}{d^2} \right\}$$

H = Loss of head of water passing through the filter bed.
K = Filtration constant. 5/g for any consistent system of units of measurement.
L = Vertical depth of the filter bed.
T = m/r = Temperature, or viscosity-density, factor for filtration.
$F = \frac{(1-f)^2}{f^3}$ = Porosity factor; f is the porosity ratio of the filter.
v = Velocity of approach over the gross area of the bed.
S = Sand shape factor.
d = Geometric mean of the rated sizes of adjacent sieves.
P = Percentage of sand by weight held between adjacent sieves.

Fair and Hatch state that a series of tests not recorded in the paper show close agreement between theory and experiments. The writer is of the opinion that the equation probably comes nearest to taking into consideration all of the factors affecting the flow of water through sand. Its disadvantages are that it has a filtration constant and it also has a shape factor which may not be very easy for one to assign a correct value.

Other Work on the Flow of Water Through Sand.—Others have investigated the flow of water through sand or porous materials, and if one is interested in studying more thoroughly what has been done in the past, the work of Slichter,[12] Baldwin-Wiseman[13] Terzaghi,[14] Chilton and Colburn[15] should be read. It is not believed that the equations used by these authors have an application in water filtration.

Additional Work on Filtering Material.—Engineering News-Record[16] in 1931, obtained the views of a few filtration engineers on the Hazen method of classifying sands. Most of those commenting on the method thought it was fairly satisfactory. At least they did not favor any of the suggested modifications which had been made up to that time.

Armstrong[17] gave an account of some of the work under his direction, in which glass tube filters containing sand varying widely in size were used. An explanation of the action of fine grained and coarse grained filters in removing the coagulated matter from water was given. The hydraulic grading of the sand after washing was studied, and curves plotted to show the grading according to size. Tests on the expansion of the sand beds when washed at various rates also were given. Armstrong states that: "In view of the fact that with fine sands most of the work of filtration takes place in the size finer than the 10 per cent size, and with coarse grained sands most of the work is affected in the portion of the bed below the 10 per cent size. The term "effective size" should be redefined or some other term such as "top size" should be substituted.

NOT MUCH ADVANCEMENT HAS BEEN MADE IN COMPUTING FILTER PERFORMANCE.

All work to date on filtration fails to give us some means of determining the most satisfactory sand for rapid sand filter beds, and we are not much better off than we were after Hazen's classical work at the Lawrence Experimental Station. Even though the effective size as set by Hazen for slow sand filters has worked fairly well for rapid sand filters when the sand is obtained from certain sources, there is a belief that it is a figure which will not hold for all sands and for all conditions.

The Need for a Better Method.—The writer shares the views of many that there is real need for a better method of classifying filter sands, yet he has not been anxious to get entirely away from the Hazen method with some new term like fineness modulus, surface modulus, size factor, sieve number, or some other such term. In 1924, he proposed use of the relation between the 1 and 10 per cent sizes to be known as the fine ratio. This was to take into account the finer material in the filter beds. It is not intended to convey the impression that this was the first suggestion of the use of the 1 per cent size, for many specifications set a limit on the fine material by stating that not over 1, 2, or 2.5 per cent of the weight of the material be less than a certain diameter. However, no ratio between the lower number and the 10 per cent size was suggested.

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EVOLUTION OF SEWAGE PUMPING AT NORFOLK, VA.

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THE city of Norfolk is so flat that it is impossible to construct sewers which drain by gravity to tidewater, except in small areas along the waterfront. Sewers in other parts of the city must be grouped in small areas, each drained to a central pumping station. As a result, the city now has in operation 21 such stations. The first one of these stations to be put in operation is the one located at the corner of City Hall Avenue and Atlantic Street, which drains all the downtown business area. It began operation approximately in 1885, being equipped with Holly plunger pumps. Of course, the sewage had to be screened but there was nevertheless considerable trouble with the pumps as well as with the screens. Within a few years there was installed at this station what we think to be one of the first centrifugal pumps for handling unscreened sewage. It was known as a Cataract pump, the casing of which was almost drum shaped, and the vanes of the impeller little different from a paddle wheel. Nevertheless, it handled the sewage very much better than the plunger pump, and it is still serviceable, as was demonstrated during the two high tides of the past summer.

However, this pump did not have sufficient capacity to handle all the sewage; and, in consequence, the then City Engineer, Mr. Brooke, worked with Morris Machine Works of Baldwinsville, N. Y., and designed a large centrifugal pump, direct connected to a compound steam engine. This pump had a 20 in. suction and discharge connections, and was supposed to pump at the rate of 13 million gallons daily, but actually it was never run up to the full speed or capacity. On the very day that the steam was first turned on the engine to operate the new pump, the plunger pump went completely out of commission, and the result was that this new pump ran continuously for the next 300 days, during which time a second unit was built and installed.

All of these pumps were above the sewage level in the suction well, and, therefore, had to be primed by a steam siphon. When it became necessary to build other stations it was recognized that it would be better to have the pumps set so low that it would fill with sewage and not require external means for priming. Accordingly, pumps were set directly in the suction well with a vertical shaft connecting the pump to a motor set on the ground floor. This made it possible to arrange automatic control for these pumps by means of float switches, and very reliable results were obtained. These pumps had narrow blade impellers, open on the lower side, and were, therefore, comparatively inefficient. Nevertheless, they were able to handle unscreened sewage including all manner of material which can get through sewer pipes. There were only occasional stoppages, when it became necessary to remove some foreign material, such as a pair of overalls, which failed to get by.

As you may readily see there were objections to having the pump submerged in the sewage, for the location constituted grounds for excuses by attendants who neglected giving the pump proper care. Accordingly the next step in advance was to build a separate pump chamber alongside the suction well with the pump set below the sewage level. Vertical shafts with motors above ground were still used, and this arrangement was in the main satisfactory.

Appearance of the Trash Pump

The pump design was not altered until about ten years ago when Wood of New Orleans designed his so-called trash pumps, which were originally intended for use in dredging. The impellers of these pumps were very wide and were shrouded on both sides, and instead of having several blades they had only two blades. The passages between these blades were so large that a sphere only an inch or two smaller than the suction connection would pass through the pump without stoppage. The blades on these impellers are so shaped that one might at first doubt whether they would operate at all as a centrifugal pump, but strange to say they produce efficiencies much higher than the older type. These pumps were manufactured by Fairbanks Morse, and more recently similar pumps have been manufactured by Yeoman's Brothers, Morris Machine Works and others; and, all of these have proven very satisfactory in our service.

The two large Morris centrifugal pumps in the station at City Hall Avenue and Atlantic Street continued in service until about six years ago, when we became convinced that we could make large savings in cost and still be reasonably sure of continuous service if we displaced these steam units with electrically driven pumps. Accordingly one steam unit was removed and three electric pumps, sizes 10 inches, 12 inches and 16 inches, were installed. These pumps were set in the same pit, hence were above sewage level, requiring a vacuum pump for priming. The power for these pumps is supplied by two entirely separate electric feed lines, each connected to bus-bars through interlocking oil switches, so that in case of trouble on either feed line the other may be thrown into service. This arrangement has given us uninterrupted service at a great saving over the steam operation.

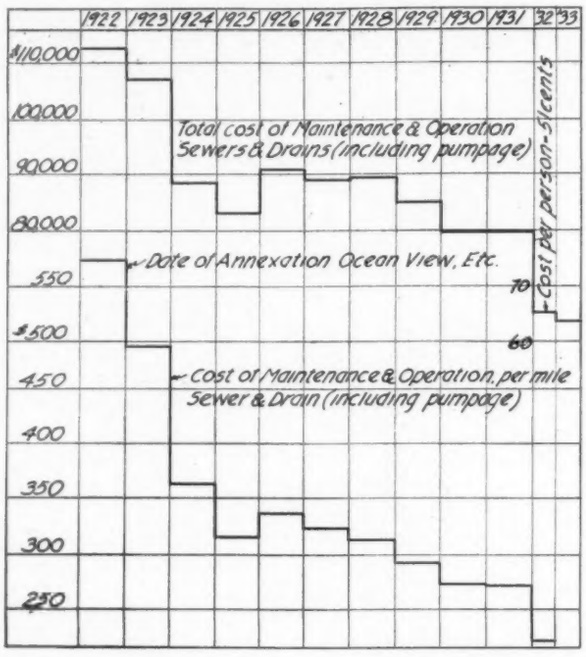
The second largest station, that on Colley Avenue, was also steam operated until recently. It had only one ten inch centrifugal pump, also connected to a small vertical compound engine, and this unit ran almost continuously for 40 years. Vertical, electrically driven pumps were installed some 12 or 15 years ago; but they gave so much trouble from stoppages due to rags, the engineers did not like to take care of them, and consequently the steam unit remained in almost continuous service. About two years ago one of the old electrics was removed and a new Yeoman's pump was installed in its place with sufficient capacity to handle the entire flow during ordinary conditions. This pump has rendered almost continuous service from that time.

The last station which we built includes an innovation in our practice consisting of the use of direct-connected horizontal pumps. Previously we had thought it necessary that the motor should be above ground, but we have found that with proper care in pouring concrete it is possible to make the pump pit practically dry. In this station the pump pit is open to the roof of the superstructure, except for small galleries on two sides, so that there is complete ventilation and no trouble from

condensation. This station is in a residential area, and, therefore, we made the superstructure of artistic appearance to resemble a small cottage.

Siphon Collecting System Developed

There is one other system of handling sewage which first had effective use in New Orleans and more recently in Portsmouth, Virginia. With this system the pumping is all done at one point, the pump well at that point being connected by siphon lines to all other collecting wells in the system. This system perhaps had its first use in Norfolk, although no further development was made of it. When the original sewer system was put in, it was found that the sewers north of Freemason Street would require a very deep line coming down Brewer Street to the City Hall Avenue pumping station. On account of a large brick building facing this street the consulting



Graphic Presentation of 11 Years of Sewer Operation and Maintenance Costs at Norfolk, Va. Showing the Material Reduction Effected by Electrification of Pump Stations and Other Improvements

engineer thought that this deep line was not feasible and was about to give up the scheme, when Mr. Brook, the then City Engineer, said that the sewage could be handled by means of a siphon. The consulting engineer did not approve of this, because it had never been tried. Nevertheless, Mr. Brook obtained authority from the City Council and constructed the siphon. The pipe is laid just below the surface from a well at Charlotte Street to the pump well in the pumping station. At the highest point in this line a connection is made to a steel chamber containing a brass screen, and from this chamber an air pipe runs to a vacuum pump in the pumping station, which removes air from the siphon. This siphon has been in continuous use every since, and as stated above, was probably a forerunner of the siphon system recently developed in New Orleans and Portsmouth. I have never seen any cost data on such a system, but I presume that the installation costs would be rather high because all of these siphon lines must be of cast iron, laid with extreme care as to grade and air-tightness. On the other hand, the cost of operation is probably less, due to having all of the pumping done at one point instead of having a large number of pumps scattered all over the city as we have in Norfolk.

If and when a sewage disposal plant is constructed in Norfolk, it will first be necessary to collect the sewage which is now discharged through many outfalls to one or two central points. Some months ago we made a tentative layout for the additional pumping stations, discharge mains, etc., and we included in this layout several such siphon lines, thereby making it possible for one pumping station to handle sewage collected in two or more wells.

Operating Costs

Speaking of operating costs I may say that the change from steam to electric power in the City Hall Avenue station effected a large saving. There was much opposition to this change, but I was convinced that a large saving could be made without sacrificing reliability. The saving proved to be not less than $10,000 a year. A large portion of this, of course, was saving the wages of three firemen whose services were eliminated. In fact, many savings have been made in all our operations. When the Division of Sewers came under my supervision in 1923 the annual cost for all purposes was $113,000, whereas the same cost in 1932 had been reduced to $66,000. During this period the total miles of sewers and drains increased from 196 to 296 miles, so that the cost of operation per mile of sewers (including pumping) has decreased in that period from $577 to $223—a reduction of approximately 61 per cent.

Acknowledgment—A paper presented before the Virginia Water and Sewage Works Association at Newport News, Va.

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Registration of Engineers in Ohio

The director of the State Department of Health of Ohio has issued bulletins pertaining to the requirements concerning registration of professional engineers who have dealings with that department. Any person practicing the professions of engineering and surveying after Jan. 1, 1934, in connection with any work of a public nature is required to be registered.

Administrative Bulletin No. 9 concerns procedure in the submission of plans to the State Department of Health for approval. Under the terms of the Engineers' and Surveyors' Registration Act, it will be necessary that plans submitted to the State Department of Health for approval shall contain evidence of registration of the designing engineer as a professional engineer.

Administrative Bulletin No. 10 relates to the supervision of operation of water purification and sewage treatment works by registered professional engineers. The State Board of Registration for Professional Engineers and Surveyors construes Section 1083-2 to mean that any one who is charged with the responsible supervision of either water purification or sewage treatment works shall be registered as a professional engineer. According to Ohio Health News it has been the practice in Ohio in the case of the small water purification plants and sewage-treatment works to provide part time technical supervision of their works by a technically qualified person, usually a man in charge of similar works in some nearby larger city. It is the understanding of the State Department of Health that the Engineers Registration Law will be complied with if part time technical supervisors of small plants are registered, providing the supervisor assumes full responsibility for the operation of the works. In order to satisfactorily comply with this latter requirement, it is obvious that the supervisor shall perform more than cursory and infrequent visits and inspections of the plant in his charge.

CHLORINATION IN SEWAGE DISPOSAL

Discussion of the Report of the A. P. H. A. Committee on Sewage Disposal

A COMPREHENSIVE review and analysis of the applications, effectiveness, and limitations of chlorine and chlorine products in domestic and industrial sewage treatment, was presented on October 10, 1933, before the Annual Meeting of the American Public Health Association at Indianapolis, Ind., by Langdon C. Pearse, Chairman, Committee on Sewage Disposal.

The report, too voluminous for reproduction in these pages, was two years in the course of preparation. In a complete manner it carefully reviews and evaluates results which have been secured in sewage chlorination practices.

The committee charged with the preparation of this report has done a valuable and painstaking job of presenting in a single, but exhaustive, report the modern status of sewage chlorination, supported by a comprehensive list of references and quotation from the literature on the subject. Having carefully examined the report which is now in press, preparatory to distribution by the American Public Health Association, it is our pleasure to compliment this committee, on which the following authorities on sewerage and sewage treatment collaborated.

A. M. Buswell	F. W. Mohlman
C. K. Calvert	Willem Rudolfs
Harrison P. Eddy	F. M. Veatch
V. M. Ehlers	P. J. A. Zeller
C. E. Keefer	Langdon C. Pearse, Chairman

Following the presentation of the report there was discussion of extent and quality to warrant its recording. The lack of facilities at the meeting and the policy of the Association in the matter of not recording or reporting extemporaneous discussion from the floor of its meetings, has made it seem desirable to reproduce, for record, the discussion in the abbreviated form presented below.

Discussion*

L. H. ENSLOW, Sanitary Engineer, The Chlorine Institute, New York City, said that he desired to compliment Mr. Pearse and his committee members on their very thorough and comprehensive report and the valuable bibliography appended. The report in full had been read prior to this presentation and it constituted a most excellent review of the published and known facts pertaining to chlorination effects in sewage treatment practices. The conclusions drawn at the end of each subject head, based on established facts, would prove highly valuable in clarifying any confusion which might exist concerning the claims for chlorination which had been advanced in the many scattered articles dealing with sewage chlorination in America and abroad.

He regretted the citation of disinfection data from the Westerly (Imhoff) Plant at Cleveland, Ohio, because the figures for efficiency (80 to 92 per cent) were not truly representative of accomplishments at numerous other plants. The figures should be cited as indicative of inefficiency of disinfection when the dosage of chlorine applied is deficient; i. e., not high enough to satisfy the chlorine demand of the strong and foul Imhoff tank effluent. As a matter of record the results recorded at the Easterly Plant at Cleveland, where only bar-screening and chlorination had been used, were superior to the Westerly Plant results. This circumstance only went to show the effect of strength and age of sewage on chlorine demand and the necessity of adding sufficient chlorine to satisfy such demand for efficiencies upwards of 95 per cent, when contact periods were less than 30 minutes. Effective chlorination of settled sewages had been proven capable of removing all but 0.1 per cent of the b. coli present. Results attained in the Huntington, L. I., studies, cited elsewhere in the report as a "classic piece of work," constituted evidence on this point. Even with the limited chlorine dosage at Cleveland, had it been added to the crude sewage ahead of the tanks higher efficiencies would have resulted with less chlorine. Prechlorination had been only recently resorted to at Cleveland and probably there, as elsewhere, the advantages of prechlorination for uniformity of disinfection, odor control and chlorine economy would become evident.

Concerning the power of chlorine to reduce the oxygen demand of effluents and otherwise function to improve stream conditions, Mr. Enslow, remarked that the results at Chapel Hill, N. C., Downer's Grove, Ill., and elsewhere had been indicative of the merits of this phase of chlorination. He was glad to see present at the meeting one of the earliest—probably the earliest—investigators of oxygen demand reduction by chlorine. He said that he was referring to the work of R. J. Morton while pursuing advanced courses in Sanitary Engineering at Harvard University, the results of which constituted a part of a thesis presented in 1926 and quoted from in the literature, but never published. The findings of Mr. Morton had since been confirmed in numerous other investigations which revealed actual reductions of 2.3 to 5 parts per million oxygen demand value for every part of chlorine applied. Mr. Enslow requested the committee chairman to insert a reference to this work in the report, because of its historical significance as the first attempt to study the effect of chlorine on putrescible bodies in sewage. In this study it was for the first time revealed that, aside from the marked retardation of biological activity in reseeded and diluted chlorinated sewages, there was an additional effect of a change which reduced the oxygen required to prevent subsequent putrefaction. Almost coincidentally studies by Whedbee and himself at Dallas, Texas, revealed the same effect; and the findings of the Chicago Sanitary District, later, had verified these observations in a conclusive manner. The first real test under practical working conditions, which could be carefully checked downstream, had been that at Chapel Hill, N. C., where the studies had been supervised and reported by H. G. Baity, Dean of Engineering at the University of North Carolina. At Indianapolis, and Flint, Mich., the effect of chlorination had not been worth while because, in each case, the stream was sludge laden below the plants and one could not expect chlorination to perform the work which should have been done by sedimentation and efficient secondary treatment. In other instances where streams were to a less degree overloaded the chlorination effect had been sufficient to tip the balance from that of almost complete oxygen depletion to

*To insure accuracy of the record, made from notes taken during the presentation, this digest of discussion has been submitted to each discussor for approval or correction prior to printing. Copies of the report may be procured, from the American Public Health Association, the Chlorine Institute, Inc., New York City, or by writing this magazine.—Editor.

that of positive oxygen balance and thereby relief from seasonal nuisance. Chlorination had likewise been effective in clearing up unsightly biological growths in somewhat over-polluted streams at several points where sphaerotilus growth predominated; and, in other instances, where algae had proved a nuisance in streams receiving highly nitrated effluents.

M. F. TRICE, Assistant Engineer, State Department of Health, Raleigh, N. C., rose to object to what appeared to be some doubt in the report as to the quality of laboratory work conducted in connection with the studies of oxygen demand reduction and stream improvement at Chapel Hill, N. C. He had had contact with the work and the methods and laboratory technic involved. In comparison with practice in leading laboratories of the country, the Chapel Hill work had been representative—including the appearance of occasional fluke results, just as are found elsewhere when B. O. D. determinations are involved. During the drought of 1930 and 1931 the results of chlorination had been established during the period of constant sewage conditions and constant low stream flow and high temperatures.

R. J. MORTON, Chief Engineer, State Department of Health, Nashville, Tenn., said that chlorination had been used at Tennessee plants for B. O. D. reduction and stream improvement, with a like degree of success as that demonstrated at Chapel Hill. He considered the availability of chlorination for this purpose an important asset in emergencies such as during periods of deficient plant performance in addition to its regular use during seasons of deficient stream flow and normal plant functioning. In a modest manner, Mr. Morton touched on his thesis work at Harvard University, which had been referred to by Mr. Enslow.

W. J. SCOTT, Chief Engineer, State Department of Health, Hartford, Conn., commented on the necessity of insuring the presence of residual chlorine in sewage if satisfactory disinfection was to be insured. Studies made at Connecticut plants had revealed that samples of chlorinated effluent should be examined on the spot or, else, treated with thiosulphate to destroy the residual chlorine before storage or transporting to the laboratory. It appeared that 0.5 p.p.m. residual chlorine and a contact period of 15 minutes should be considered the minima when disinfecting settled sewages. On this score prechlorination had distinct advantages and in practice had been so proven where otherwise the contact periods might prove inadequate or where fluctuations in quality or quantity of sewage was likely to be pronounced.

E. SHERMAN CHASE, Metcalf and Eddy Engineers, Boston, Mass., commenting on heavy chlorination intermittently for control of the sprinkling filter fly (psychoda alternata) felt that properly applied the process had merit. Cases of material relief were cited—the most recent being at Allentown, Pa., in which the effective dosage had been 50 p.p.m. chlorine applied to the syphon chambers every 10th day for a period of 2 hours.

Mr. Chase cited the effectiveness of applications of chlorinated lime to a mill pond on the polluted Neponset River for correcting an odor nuisance pending rain which had provided the needed dissolved oxygen by natural dilution. He also cited cases of super chlorination of industrial waste to destroy its color and otherwise improve the condition of a stream sufficiently to render it again useful to industry below.

L. F. WARRICK, Chief Engineer, State Board of Health, Madison, Wis., cited the efficacy of chlorine in rendering waste from a kraut factory suitable for discharge into a water course. The treatment which involved chemical precipitation, rapid sand filtration of the effluent and heavy chlorination, had been found to reduce the putrescibles of the waste by 75 per cent in terms of oxygen consumed (permanganate reduction) values; and, by 87 per cent when measured in terms of 5-day biochemical oxygen demand value. Chlorination had been provided principally to reduce the rate of depletion of dissolved oxygen in the small stream receiving the waste.

C. A. HOLMQUIST, Director, Division of Sanitation, State Department of Health, Albany, N. Y., stated that his department was at all times prepared to provide emergency chlorination of sewage where needed. To protect bathers in the Hudson River, five municipalities above New York City had been required to provide chlorination of the crude sewage pending more adequate treatment. Analyses of river water in the bathing areas had revealed a surprisingly marked improvement. At one or two points in New York State chlorination of milk wastes, to reduce its B. O. D. value and correct nuisance, had been very satisfactory. The same could be said concerning chlorination of cannery waste following treatment by chemical precipitation.

C. M. BAKER, Consulting Engineer, Madison, Wis., said that the report had omitted reference to an important function of chlorination in stream pollution control. He referred to the situation in the paper and paper-board industry, wherein internal chlorination made it feasible to practice re-use of the "white-water" formerly wasted to streams. The closing up of the system had saved money for the manufacturer and grief for the stream control authorities, by the marked curtailment of pollution and reduced water consumption by the mills. The ammonia chlorine treatment of the recirculated waste waters had been particularly efficacious in preventing biological slime depositions and putrefaction in the system. The same general scheme might well be considered for other industrial establishments, now polluting streams or loading treatment works by sending valuable ingredients and heat units to the sewer to create a pollution problem. In solving stream pollution, industry might start its "charity" right at home.

F. H. WARING, Chief Engineer, State Department of Health, Columbus, O., stated that among the beneficial effects produced by chlorination of plant effluents, one of the most evident and valuable was the effect of chlorinated effluent in keeping small streams free of algae and slime growths. He cited the experience of Fostoria, O., where sprinkling filter effluent, discharged to an almost dry stream bed, had created algae growths which were unsightly. Riparian owners had been successful in several stream pollution suits, notwithstanding the good operating results of the local sewage treatment works. During the three past years chlorination of the effluent, to maintain 0.4 p.p.m. residual chlorine or thereabouts, had cleared up the stream condition and legal actions had ceased. He had recently made a personal inspection of stream conditions several miles below the plant—to find fish living one-half mile down stream although the flow was almost entirely composed of sewage effluent. The Fostoria experiences indicated the desirability of chlorination of highly oxidized effluents discharged into small streams.

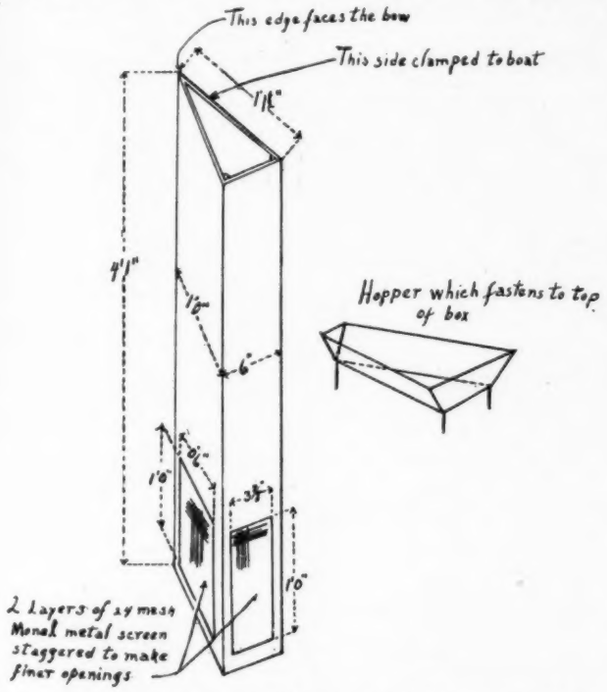
In reply to a question, Mr. Waring stated that game wardens and conservation officials were satisfied with the conditions of the stream. Carp could be found immediately below the plant and several other varieties of fish were observed at the half-mile point, below which the residual chlorine had disappeared.

METHOD OF APPLYING COPPER SULPHATE AT BALTIMORE, MD.

By PAUL SMITH*

IN the summer of 1930 it was decided to treat Back River, which is a tributary of Chesapeake Bay and into which the treated effluent from the Baltimore sewage works discharges, with copper sulphate for the purpose of checking algae growths.

A few preliminary tests were made to determine the most advantageous method of applying this chemical. One hundred pounds of the crystals were put into burlap sacks and hung one on each side of a power boat. The speed of the boat was quite slow due to these bags. Because of the large surface of sulphate exposed to the water, the material dissolved more rapidly than it should. As the boat proceeded on its course the amount of sulphate in the bags became less, and the speed of the boat increased. Consequently the water was under-dosed in many places. As it was impossible to tell when the

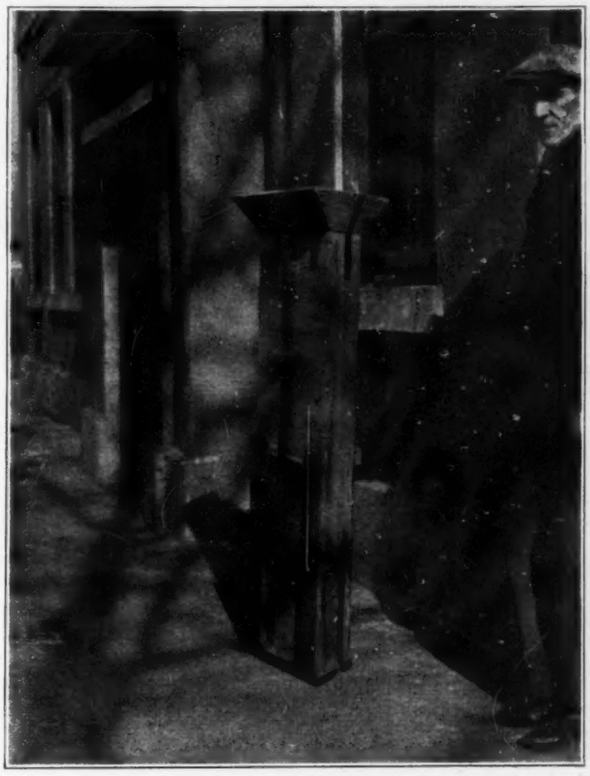


Sketch of Copper Sulphate Solution Box (Slide Gate to Control Rate of Solution Not Shown. See Photograph of the Box)

copper sulphate had completely dissolved, the bags had to be removed from the water. To do this with the boat in motion was almost impossible for one man, and usually the boat had to be stopped. Fifty-pound bags of copper sulphate were placed in nets with the same unsatisfactory results, so the use of nets was abandoned.

Finally, a wooden box was built for holding the copper sulphate. This box, as the sketch shows, is about 4 ft. long, and has a triangular cross-section with a small hopper at the top to facilitate the dumping of chemicals into the box. Near the bottom of the box are two openings, covered with two layers of twenty-four mesh monel metal screen, staggered to make finer openings. The side adjacent to the boat has no openings, and was fastened to the boat with clamps. The larger opening faced forward and the smaller opening the rear. In comparison with the use of bags, the box offered very little resistance in the water, so that the boat could be run at a constant speed.

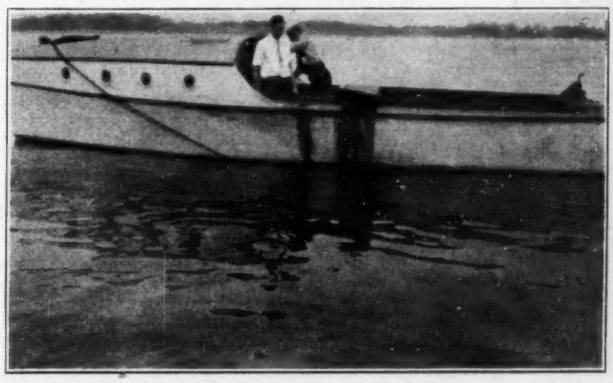
The capacity of the box including the hopper was 100 lb. The first time the box was used it vibrated, and had a tendency to work loose, but by securing the bottom of



Side and End View of the Solution Box (Solution Control Gate in Wide Open Position)

the box to the bow of the boat with a rope, as illustrated, this difficulty was overcome.

It was found that 50 lbs. of large crystals could be dissolved in 10 minutes, but with small crystals the time was reduced to 6½ minutes. In order to dissolve all the sulphate and at the same time cover the desired area, the rate at which the sulphate dissolved was controlled by



Solution Box in Place on Boat. Rope Attached to Bottom to Keep End from Kicking Back

*Assistant Chemist, Bureau Sewers, Baltimore, Md.

altering the screen area with adjustable wooden covers, placed over the screens. As the boat proceeded, a swirling motion of the water entering through the screened opening was set up in the lower part of the box, but the upper part remained dry. An accumulation of lint from the bags, which contained the sulphate, and dirt from the river water partially blocked the screens, and the adjustable covers had to be removed at intervals. To overcome this disadvantage a wooden sliding device (gate) was provided to cover the front screen.

In practice, 50 lbs. of sulphate were placed into the box, and a mark made on the box at the top of the crystals. Another 50-lb. portion was then immediately added, and the time for the above mentioned mark to be seen was observed. In this manner the sulphate was added, 50 lbs. at a time. The slide at the bottom of the box was adjusted, depending upon the time necessary for the boat to cover the area to be dosed. If the interval necessary to dissolve 50 lbs. increased, the area of the screen at the bottom of the box was enlarged by raising the adjustable slide. As the screens became clogged, this slide was raised, so that the time for the 50 lbs. to dissolve was kept fairly constant. If the screens became quite clogged they were brushed just before the next trip, the dry accumulation being readily removed in this manner. On one occasion a blow torch was used to burn off the accumulation of material on the wires.

By use of this box 1,250 lbs. of copper sulphate were distributed evenly over an area of 1.2 sq. mi. in less than four hours and with less than half the labor required when, previously, burlap sacks had been used.

The Baltimore Sewage Treatment Works is under the general control of B. L. Crozier, chief engineer, Department of Public Works. George E. Finck is sewerage engineer and G. K. Armeling, plant superintendent. C. E. Keefer is engineer in charge of sewage disposal and E. C. Cromwell is principal sanitary chemist.

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Sewer Gas Kills Two at Lorain, O.

Two employes of the Sewer Department of Lorain, Ohio, lost their lives March 13, while flushing out a deep pit under a manhole. Press reports indicate that one of the victims entered a manhole, hose in hand, for the purpose of flushing out a 40-ft. pit; that he had partly finished his task and had almost reached the top of the ladder on his way to the surface when, overcome by gas, he lost his hold and fell back to the bottom. One of his companions immediately went down after him, ignoring the protest of a third workman, who hastened to call the fire department, with both rescue and resuscitating equipment. The department answered the call promptly, but arrived too late to save either the first victim or his would-be rescuer.

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Capacity of Water-Power Plants Increased About 100,000 H. P. in 1933.—The total capacity of water wheels at water-power plants in the United States on Jan. 1, 1934, according to the annual report just released by the Department of the Interior through the Geological Survey, was 15,913,451 horsepower, an increase during the year of 95,500 horsepower, or 0.6 per cent. Five States—New Hampshire, Massachusetts, Pennsylvania, Michigan, and Wisconsin—show an increase in capacity of water wheels of more than 10,000 H. P. from the figures published in the previous annual report. Washington shows a decrease of more than 10,000 H. P., and a few states show minor decreases, due to abandonment of some plants and changes in capacity of others.

Association Meetings Scheduled

April 16-18—**Florida Section, A. W. W. A.** Daytona Beach, Fla. Secretary, L. G. Lenert, Chief Engineer, State Department of Health, Jacksonville, Fla.

April 18-19—**Illinois Section, A. W. W. A.** Hotel Pere Marquette, Peoria, Ill. Secretary, A. E. Skinner, Pitometer Company, 5311 Kenmore Ave., Chicago, Ill.

April 19-20—**New York Section, A. W. W. A.** Arlington Hotel, Binghamton, N. Y. Secretary, R. K. Blanchard, Neptune Meter Co., 50 E. 42nd St., New York, N. Y.

April 20-21—**Montana Section, A. W. W. A.** Billings, Mont. Secretary, H. B. Foote, State Board of Health, Helena, Mont. (School for Water Works Operators precedes meeting April 18-19.)

April 25-27—**Kansas Water Works School.** University of Kansas, Lawrence, Kan. Secretary, Ernest Boyce, Chief Engineer, Kansas State Department of Health, Lawrence, Kan.

April 30—**New England Sewage Works Association.** Pickwick Arms Hotel, Greenwich, Conn. Secretary, F. W. Gilcreas, State Department Health, Albany, N. Y.

May 1—**New England Water Works Association.** (Spring meeting.) Hotel Brunswick Arms, Greenwich, Conn. Secretary, Frank Gifford, 715 Tremont Temple, Boston, Mass.

May 3-4—**Maryland-Delaware Water and Sewage Works Association.** Wardman Park Hotel, Washington, D. C. Secretary, A. W. Blohm, 2411 N. Charles St., Baltimore, Md.

May 10-12—**Pacific Northwest Section, A. W. W. A.** Hotel Eugene, Eugene, Ore. Secretary, E. C. Willard, 720 Corbett Bldg., Portland, Ore.

June 4-8—Annual Convention of American Water Works Association. Hotel Commodore, New York City. Secretary, B. C. Little, 29 W. 39th St., New York City.

June 5-6—**Arizona Public Health Association.** Prescott, Ariz. Secretary, Jane H. Rider, Director State Laboratories, Tucson, Ariz.

June 15-16—**New York State Sewage Works Association.** Jamestown, N. Y. Secretary, A. S. Bedell, State Department of Health, Albany, N. Y.

June 25-27—**Pennsylvania Water Works Operators' Association.** State College, Pa. I. M. Glace, Secretary, State Department of Health, Harrisburg, Pa.

June 28-29—**Pennsylvania Sewage Works Association.** State College, Pa. L. D. Matter, Secretary, State Department of Health, Wilkes Barre, Pa.

July 12-14—**Virginia Section, A. W. W. A.** Martinsville, Va. Secretary, H. W. Snidow, State Department of Health, 601 State Office Building, Richmond, Va.

Aug. 22—**West Virginia Conference on Water Purification.** Hotel Windsor, Wheeling, W. Va. Secretary, J. B. Harrington, State Department of Health, Charleston, W. Va.

Aug. 23-24—**Central States Section, A. W. W. A.** Hotel Windsor, Wheeling, W. Va. Secretary, H. L. Nelson, U. S. Pipe and Foundry Co., 2435 Koppers Bldg., Pittsburgh, Pa.

Sept. 3-6—**Annual Meeting of American Public Health Association.** Pasadena, Calif. Willimina R. Walsh, Secretary, 450 7th Ave., New York City.

Sept. 17-19—**Rocky Mountain Section, A. W. W. A.** Santa Fe, N. M. Secretary, B. V. Howe, Board of Health, Denver, Colo.

Oct.—**California Section, A. W. W. A.** Long Beach, Calif. Secretary, J. E. Phillips, Department Water Supply, 207 Broadway, Los Angeles, Calif. (Exact date later.)

Oct. 15-18—**Southwest Water Works Association.** Hotel Hilton, Waco, Texas. Secretary, Lewis A. Quizley, Superintendent, Water Department, Fort Worth, Texas.

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A Novel Method of Thawing Mains

A newspaper report, which sounds more like just that than the truth, has this to say about thawing mains while fighting a large fire in Neptune, N. J., during one of the sub-zero spells of last winter: "Firemen were handicapped by the cold. Some of the mains had been frozen and it was necessary to notify the water company, which *sent steam through the pipes.* Fifteen minutes lapsed while the pipes were thawed in this manner."—Anyway, it made a good newspaper story.

EDITORIALS

Industry Should Pay

INDUSTRIAL PLANTS that pollute streams, to the extent that they are useful as sources of potable water supply only after difficult treatment at an added expense to municipalities or water companies, cannot continue in their disregard of this important question. Consumers are coming to be more and more intolerant of inferior quality of the water served them; water works operators and managers more appreciative of this demand and are meeting it to the best of their abilities. Chemists have developed and perfected processes and materials capable of producing palatable and safe water from supplies so polluted as to render them unfit for domestic use when relying on the simpler and more economical treatment processes.

As measures of emergency treatment, these complex and expensive procedures are of great value; but, is it fair to expect the consumer downstream to stand the added expense in order that upstream municipalities or industrial establishments may continue to pollute streams on the excuse of lack of a proven practical remedy in the way of treatment process for some particular industrial waste—or, on the plea of expense involved?

Stream pollution is being somewhat reduced, but there is much more to be done that can be done without crippling industry. In the meantime, is it more than might be reasonably demanded by communities, required to employ expensive super-processes of water purification to render water agreeable to drink, that the responsible polluting industrialists pay the bill incurred for such extra treatment? This should be the least costly and simplest solution of such a problem which a polluter could wish to have proposed to him. He would probably jump to the opportunity of satisfying the damaged municipality or water company by such a simple expedient—one which places the responsibility of producing results on the complainant; and, at only a fraction of the cost which would be involved in reducing the pollution at the source.

A case of this general nature has recently come on record. The Great Lakes Sugar Company, located at Blissfield, Mich., on the River Raisin above the intake of the Dundee, Mich., purification plant, being held responsible for pollution productive of tastes and odors in the latter's water supply, settled with Dundee authorities their claim against the company, amounting to the extra cost of water treatment incurred in removing such tastes. The case against the sugar refinery, operated seasonally, was in this instance plain. The State Stream Control Commission and State Department of Health authorities assisted the village of Dundee in presenting its demands for better control of pollution and reimbursement of the village for expenses incurred in heavy pre-chlorination followed by super-dosages of powdered carbon required for taste removal. Here is a precedent from which other damaged communities, with the assistance of state agencies, might benefit.

Where any form of agreement is entered into with a polluter, which involves payment of extra costs of treatment, the authority receiving such payments should protect itself against any possible loophole which allows the polluter freedom from suit requiring curtailment of pollution at any future time. Otherwise pollution may be later increased to a point from which contamination of the supply should be reduced, for reasons not foreseen at the time of entering the agreement.

In many instances reimbursement of municipalities for the added cost of treatment, for which an industry is held responsible, may be tentatively found to be a satisfactory settlement of damages. In any event industry should be expected to take the fair, non-difficult and inexpensive course of paying their share of the bill for water purification, while taking steps to curtail pollution and relieve the loadings on the municipal plants. The Dundee case is one not to be overlooked.

Progress in Sludge Thickening

THE "bugaboo" at activated sludge plants, employing digestion, has been the foul (process-upsetting) supernatant liquor. The great volume of liquid passing through digesters, which are fed with thin activated sludge, has been responsible for: accentuation of the supernatant liquor problem; expense for constructing oversize digesters; difficulty of maintaining desired temperatures of the sludge therein.

To lessen this difficulty, surplus activated sludge has been bled to the crude sewage for settling out and consolidation with the crude solids in primary tanks. Many operators found this scheme productive of inferior primary effluent, resulting in increased loadings and frequently disastrous debilitation of the activation process. Other methods of reducing the water content of the wasted activated sludge prior to its delivery to digesters have in consequence been tried.

Goudey and Bennett, at the Los Angeles Experimental Plant, realizing the necessity of sludge volume reduction, first tried thickening the wasted activated sludge by plain settling. Later, lime and other materials were added to it to assist the process. Later still, they evolved the scheme of withdrawing sludge in the form of aeration tank liquor for thickening in separate tanks to produce a sludge as dense as crude sludge itself (5 per cent solids)—the two being pumped separately or simultaneously to digesters. In procuring such concentration it became necessary to hold the sludge in an asceptic condition to preclude floc dispersion or septic action and bulking. For the purpose, chlorine was added to the "top water" near the inlet end of a continuous flow thickener (WATER WORKS AND SEWERAGE, May, 1933).

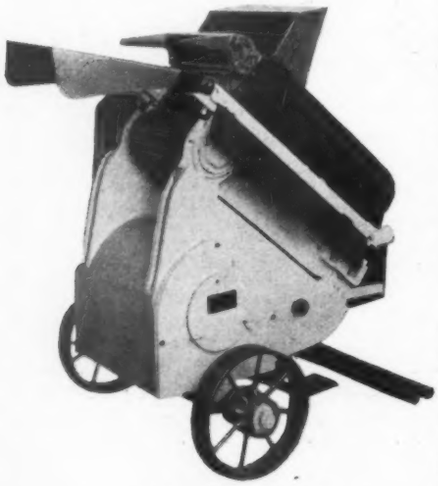
The Los Angeles application was developed on an experimental plant scale. In this issue, however, a featured article by D. Travaini tells of the successful adaptation of essentially the same process on a large scale at the Phoenix, Ariz., plant, and, at a considerably reduced chlorine usage; namely—an equivalent of 5 lbs. or less per million gallons of sewage treated. As at Los Angeles, the most satisfactory scheme tried by Travaini involves sludge withdrawal in the form of mixed liquor taken from the aerating tanks. An effective use of the 200 g.p.m. (continuous flow) of thickener effluent, containing chlorine, has been found in its discharge to the crude sewage to check septization during its passage through the primary clarifiers and thus minimize odor production and improve clarification—contituting an interesting dual usefulness of the process.

The thickening scheme, developed at Los Angeles and proven at Phoenix, which reduces the volume of sludge liquor by 80 per cent, deserves the close attention of designers and operators of activated sludge plants equipped for digestion of mixed sludges. Thickening will materially reduce the supernatant liquor and thin sludge problems of the activated sludge process. Thickening in conjunction with stage digestion should all but eliminate the problem.

NEW EQUIPMENT AND MATERIALS

Sludge Disintegrator and Blender

A novel Sludge Disintegrator and Blender manufactured by the Royer Foundry and Machine Company, Wilkes-Barre, Pa., was shown for the first time at the recent meeting of the New Jersey Sewage Works Association, a unit at the Trenton Sewage Treatment Works being used for demonstration. The machine is compact and easily portable, and employs a simple but efficient scheme of granulating damp sludge cake. Through an open hopper travels an endless belt (studded with springs), at a fairly high rate of speed, and on a 55 degree incline. The sprigs form small pockets and comb off granules of sludge which are literally projected by centrifugal force from the traveling belt as it rounds the upper pulley to return from the elevated discharge end. A series of hanging flexible clappers, forming a sweep at the discharge end, hold back all sludge particles not small enough to drop into the pockets between the sprigs. The effect is that of an old fashioned curry comb used on horses and the manufacturers refer to the operation as one of "combing" the sludge cake into granules. Scrap, nails, pebbles, etc., do not drop between the sprigs but gravitate to the lower end of the belt-bottomed hopper to be discharged to the rear when the belt is running free of sludge cake. The sludge cake is thoroughly disintegrated, aerated and graded at one simple and low power cost operation. Mixing of one or more fortifying ingredients with sludge cake, to raise its fertilizer value, can be effectively and simply done by the machine during the disintegrating operation. The Royer Disintegrator comes in several models; for descriptive literature address, Royer Foundry and Machine Company, Kingston Station, Wilkes-Barre, Pa.



Royer Sludge Disintegrator

"G. E." Pipe Thawing Generators

The severity of the past winter, with its record of sub-zero temperatures, has placed the electrical thawing of frozen pipes in the limelight. As much was evident in the Round Table of Cold Weather Troubles held at a recent meeting of the New England Water Works Association.

According to General Electric Company engineers, arc-welding generators, because of their special electrical characteristics are extremely well suited to the work. High current (amperage) is required at relatively low voltage. The lead wires from the generator are connected to the pipe or piping system so as to include the frozen section in the electric circuit. The heavy current warms the pipe and shortly melts the ice sufficiently for it to flush through the line. The current required and the time necessary to effect thawing depend on the metal, the size and length of the pipe. For instance, it has been the experience of some users that 250 amperes will thaw a ¾-in. pipe, 300 ft. long, in from 3 to 10 minutes—and again that a 3-in. pipe 100 ft. long will take nearly an hour with the current in the neighborhood of 500 amperes. Voltages involved vary widely, usually between 10 and 50 volts being required. It is therefore apparent that a welding generator, whose output voltage can be varied over a considerable range for several different current values, is well adapted to thawing as was proven during the winter just past.

For further information address General Electric Co., Schenectady, N. Y.

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A Tougher "Trimo" Pipe Wrench

The new "Trimo-Alloy" pipe wrench is made of special heat-treated chrome-molybdenum, manganese and nickel steel alloy. The popular "Trimo" swinging frame, of precision tool design, is still featured to give double strength; double safety; double service. The Trimont Manufacturing Company of Roxbury, Mass., feature a photograph showing a truck (6,140 lbs.) suspended from the handle of their 24-in. wrench gripping a round steel bar, without slip or wrench distortion. They call it the strongest, safest pipe wrench ever made because it withstands more than 3 times the standard strain test of the U. S. Navy for pipe wrenches. Features: Rounded top and bottom threads (on alloy steel jaws and nuts) will not strip or burr; replaceable lower jaw saves buying a whole new handle when jaw is worn or dull; deeper cut teeth wear three times as long; frame four and one-half times stronger than before; sizes 6 to 24 ins.

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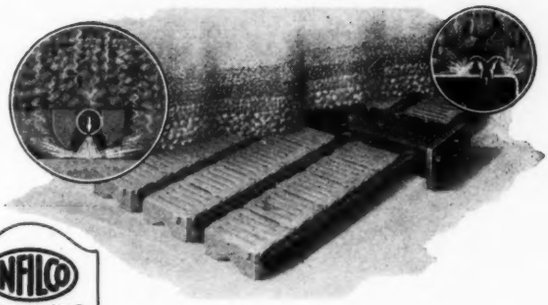

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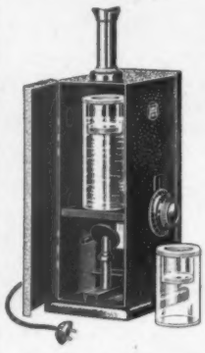

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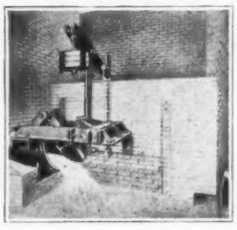

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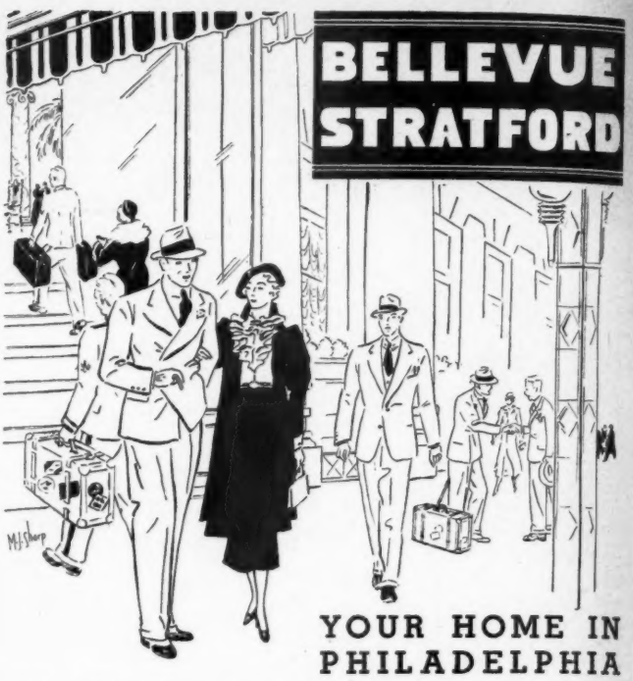

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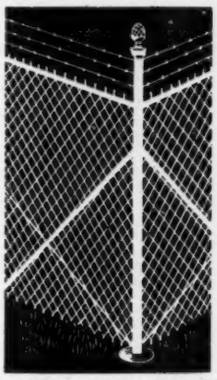

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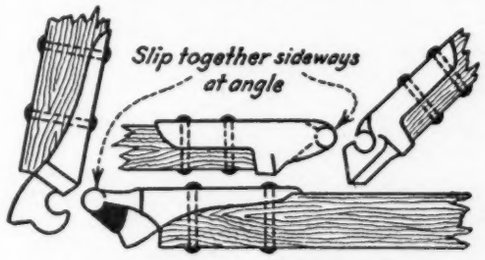

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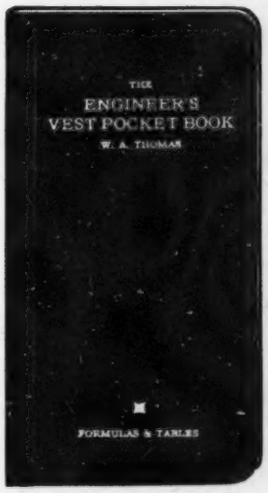

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